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BULLETIN

DE LA

SOCIÉTÉ FOUAD Ier D'ENTOMOLOGIE

anciennement :

Société Entomologique d'Egypte (1907-1921)
et *Société Royale Entomologique d'Egypte* (1922-1937)

FONDÉE LE 1er AOUT 1907

PLACÉE SOUS LE HAUT PATRONAGE DU GOUVERNEMENT EGYPTIEN
PAR DÉCRET ROYAL EN DATE DU 15 MAI 1923

LE CAIRE
—
IMPRIMERIE PAUL BARBEY
—
1953

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A Review of the Hemiptera Heteroptera known to us from Egypt

by Prof. Dr. H. Priesner and A. Alfieri

INTRODUCTION

The following account of the Hemiptera Heteroptera of Egypt does not lay claim to completeness. It is chiefly based on the collections within reach, particularly that of the Ministry of Agriculture, the richest of all, that of Alfieri, rich in species, that of the Fouad I Entomological Society (material collected by the late G. Ferrante, the late Dr. W. Innes Bey and E. Chakour), and finally Priesner's small collection, mainly consisting of material collected at a light trap at Meadi and in the neighbouring desert.

In the course of the years we have completed and emended the list which is not a simple compilation, but is based on a careful study of all the collections available. The names are founded on identifications given by various specialists and partly by ourselves. In the 1920's and before, G. Horváth, A. L. Montandon and E. de Bergevin have determined some material. Later on, in the 30's, H. Lindberg and K. Schmidt were consulted on various doubtful species. Most of the Ethiopic elements were studied by W.E. China, recently assisted by N.C.E. Miller and R. J. Izzard, and a great number of specimens were named by E. Wagner. L. Hoberlandt revised some of the semi-aquatic genera. Much of the material was identified and checked by ourselves. To W. E. China and E. Wagner we are also much indebted for informations on the separation of species, and on literature not obtainable in Egypt, and both these experienced specialists corrected a good number of wrong identifications of previous determinators. Copies of descriptions of several North African species we received from L. Mader (Vienna) and H. Hamann (Linz).

Over 40 species new to science were discovered, and many new records are given. We thought it advisable to add brief keys for the higher groups,

the genera and species, in order to facilitate the work of students of these insects, a task that is rendered particularly difficult, owing to the lack of a Monograph on the Heteroptera of the Mediterranean and adjacent regions, except that on the Pentatomidae by J. Vidal. The attached index of literature may be another help to entomologists interested in the Heteroptera of this country.

Many species, not contained in this paper, may be discovered in the future, and even from the palaearctic part of Egypt new records on species known from neighbouring countries, and even new species, are to be expected, especially of the family *Miridae*. Additions to this list may be acquired by intensive collecting, whereby particular care will have to be taken as to the handling of the *Miridae* which should not be mixed with other material, in the killing bottles.

Any student interested in the faunistic regions of Egypt may be referred to a recent publication, in which geographical and botanical details are discussed, namely E. P. Wiltshire's « Lepidoptera of the Kingdom of Egypt » (this Bulletin, vol. XXXII, 1948, pp. 204-216, and vol. XXXIII, 1949, pp. 432-457). To Wiltshire's notes on the zoogeographical regions, wherein this author correctly stresses the fact that the oases are more eremical in character than the Nile valley and Delta, we should like to add that the oasis Siwa accomodates a number of truly Mediterranean elements, differing in this respect from the other oases. This shows that the width of the Mediterranean belt varies greatly, though having in some parts (e.g. at the desert road Cairo-Alexandria) a depth of only about 60 kilometres.

Wind plays a great part in the distribution of insects. In this respect some observations made at Fayed (Bitter Lake) from 1942 to 1944 we consider worth recording. Strong winds or wind spouts coming from the north or north-west used to suddenly bring a great quantity of insects into the limited area of observation where only a few vegetables and flowers were grown. One day there was thus an invasion of various cotton insects, as e.g. *Oxycarenus hyalinipennis*, obviously carried by the wind from cultivations at least 20 kilometres distant; another day, there appeared *Scantius aegyptius* in great numbers. These insects always disappeared within a few days, as they dispersed in the desert. We had to mention this observation since it is not commonly known to what extent wind interferes in the distribution of insects, and that single specimens found on a certain biotop must therefore not necessarily belong to it. This does not mean, however, that e.g. *Phricodus aegyptiacus* Izz. or *Sjoestedtina robusta* Dist. are not natives of the desert valleys of Middle Egypt, though they are new to the palaearctic regions : they breed in our desert valleys. We are not so certain about

Macrocoris flavicollis Sign. or *Microvelia waelbroecki* Kirk. whether they are regular inhabitants of the palaearctic part of Africa or not, for water-bugs are apt to travel over very wide areas.

The fauna of the Nubian mountains, e.g. Gebel Elba of the south eastern corner of Egypt, is predominantly Ethiopic; nearly all species recorded from the Elba mountains appertaining to this geographical category, where the following species belong : *Callidea duodecimpunctata* (F.), *Diplorys cordofana* (Mayr), *Phyllocephala albicornis* Horv., *Cletus borealis* Bl., *Stenocephalus* spp. (p.p.), *Tenosius* sp.n., *Polycrates consutus* (Germ.), *Lachnophorus* sp., *Taphropeltus* sp.n., *Compseuta montandoni* Dist., *Sphedanolestes pulcher* Schout., *Coranus blanditus* Mill., *Coranus priesneri* Mill., *Charitocoris subglaucus* K. Schm., *Paramimus quinquemaculatus* E. Wagn., *Psallomimus bicoloripes* E. Wagn., *Halobates hayanus* B.Wh., and others.

In our lists of the species the note "all the year" always refers to the adult insect.

It may be useful to collectors to mention that especially species of the families *Pentatomidae, Coreidae, Myodochidae, Reduviidae* and *Tingidae* are more common in autumn, while the *Miridae* and *Anthocoridae* are prevalent, as a rule, from April to July.

KEY TO FAMILIES

1 (2) Eyes wanting. Body with combs of ctenidia as in the *Aphaniptera*. Antennae and tarsi 4-segmented, rostrum 3-segmented. Hemielytra reduced, without membrane. Parasitic on bats ..... **POLYCTENIDAE Westw.**

2 (1) Eyes well developed. Body without combs of ctenidia.

3(58) Antennae protruding, often long, 3-5-segmented.

4(49) Terminal tarsal joint not split, claws inserted at apex, not subapically.

5(12) Antennae 5-segmented. Scutellum usually large, at least one-half as long as abdomen, seldom scutellum smaller.

6 (7) Body globular, often broader than long. Tarsi two-segmented. Antennae longer than body ..... **PLATASPIDAE Dall.**

7 (6) Body not globular, or tarsi 3-segmented.

8(11) Claws conspicuous. Terrestrial forms.

9(10) Tibiae with a row of conspicuous spines, fossorial. Five sternites of abdomen visible (exclusive of genital segment) .... **CYDNIDAE Billb.**

10 (9) Tibiae seldom fossorial, usually without spines; if such are present, six abdominal sternites visible ..... **PENTATOMIDAE Leach**

11 (8) Tarsi without claws. Very small forms. Abdomen with fine, silvery pubescence. Semi-aquatic **cf. NAEOGEIDAE Kirk. (HEBRIDAE Fieb.)**

12 (5) Antennae 4-segmented.

13(14) Body exceptionally long and slender, almost needle-shaped. Eyes about in the middle of the long, club-shaped head. Rostrum 3-segmented. Living on surface of water ..... **HYDROMETRIDAE Billb.**

14(13) Body not needle-shaped.

15(16) First two antennal joints small, joints 3 and 4 long, fine, pilose, Very small (1 mm. or less), convex, blackish insects .... **SCHIZOPTERIDAE Reut.**

16(15) Not the above characters combined.

17(18) Scutellum large, attaining about middle of abdomen. Head and prothorax with yellow spines. Tarsi 3-segmented, rostrum 4-segmented. Suggesting *Coreidae* ... **cf. PENTATOMIDAE, genus PHRICODUS Spin.**

18(17) Scutellum smaller.

19(24) Tarsi 2-segmented, rostrum 4-segmented. Body sometimes reticulate. Smaller forms.

20(23) Surface reticulate, body and elytra more strongly sclerotized.

21(22) Cheeks little prolonged. Pronotum about pentagonal, triangularly produced behind, usually covering scutellum. Body distinctly reticulated ..... **TINGIDAE Costa**

22(21) Cheeks much produced. Pronotum trapezoidal, hind margin fairly straight. Scutellum free ..... **PIESMIDAE A.S.**

23(20) Surface not reticulated, body and elytra less strongly sclerotized. Suggesting *Anthocoridae*, but females brachypterous .... **MICROPHYSIDAE Dhrn.**

24(19) Tarsi 3-segmented.

25(36) Rostrum 3-segmented. (Antennals 3 and 4 sometimes filiform).

26(27) Ocelli wanting. Hemielytra much reduced, wings wanting. Body strongly flattened ..... **CIMICIDAE Latr.**

27(26) Ocelli present.

28(29) Smaller, depressed forms, the hemielytra of which possess a *cuneus*. Embolium present .... **ANTHOCORIDAE A.S.**

29(28) Hemielytra without a *cuneus*.

30(31) Rostrum long, attaining apex of meso- or metasternum. Legs normal. Metasternum without orifices of odoriferous glands. Littoral .... **ACANTHIIDAE Leach (SALDIDAE Costa)**

31(30) Rostrum short, stout, metasternum often with orifices of odoriferous glands.

32(33) Segment 1 of rostrum provided with spines. Three ocelli on a hump. Eyes very large, legs very slender. Similar to *Saldidae* .... **LEPTOPODIDAE Costa**

33(32) Rostrum unarmed. Two ocelli present.

34(35) All legs simple, slender. Very small, brown, flattened form, suggesting an *Anthocorid* ..... **JOPPEICIDAE Reut.**

35(34) Fore legs raptorial. Mostly large forms ..... **REDUVIIDAE Latr.**

36(25) Rostrum 4-segmented.

37(40) Hemielytra with *cuneus*, without longitudinal ribs. Ocelli wanting.

38(39) Membrane with bipartite cell ... **MIRIDAE Dhrn. (CAPSIDAE Burm.).**

39(38) Cell of membrane not divided. Habitus of *Anthocoridae* .... **TERMATOPHYLIDAE Reut.**

40(37) Hemielytra without a *cuneus*, with longitudinal ribs.

41(42) Tarsi without arolia. Membrane at base with two longitudinal cells, and numerous veins emerging from them. Fore legs raptorial .... **NABIDAE Costa**

42(41) Tarsi with arolia.

43(44) Ocelli wanting (1), Red and black coloured species .... **PYRRHOCORIDAE Fieb.**

44(43) Ocelli present.

45(46) Membrane with numerous veins, often even reticulate. .... **COREIDAE Leach**

46(45) Membrane with few veins.

47(48) Legs and antennae very long and fine, antennal joints and femora usually clubbed at apex. Antennal 1 much longer than head. .... **BERYTIDAE Fieb. (NEIDIDAE Reut.)**

48(47) Legs and antennae not unusually fine. Antennal joints and femora not clubbed at apices. Atennal 1 shorter than head or as long as it. ..... **MYODOCHIDAE Kirk. (LYGAEIDAE Schill.)**

49 (4) Terminal segment of tarsi either split, with claws inserted between, or claws inserted pre-apically, or wanting.

50(51) Antennae 5-segmented. Rostrum 4-segmented. Tarsi without claws, but with membraneous appendage. Membrane of hemielytra without veins and fused with clavus without suture. Very small forms. Semi-aquatic. ..... **NAEOGEIDAE Kirk. (HEBRIDAE Fieb.)**

51(50) Antennae 4-segmented. Semi-aquatic forms.

52(53) Body filiform; head very slender, eyes inserted at middle of it Rostrum 3-segmented. Ocelli wanting..... **cf. HYDROMETRIDAE Billb.**

53(52) Body not needle-shaped. Eyes not far distant from pronotum.

54(55) Rostrum 4-segmented. Middle and hind legs approximated, far apart from fore legs, and much longer than the latter. .... **GERRIDIDAE Leach**

(1) Only in the genus *Camptocera* (length 2 mm., brown) of the family *Myodochidae*

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the ocelli are wanting.

55(54) Rostrum 3-segmented.

56(57) Legs long and slender. Metasternum with orifices. Body shining. ... . **MESOVELIIDAE Dgl. Sc.**

57(56) Legs shorter and stouter. Metasternum without orifices. Body usually clothed with silvery pubescence. ..... **VELIIDAE Dhrn.**

58 (3) Antennae inserted in a groove on underside of head, very short. Aquatic insects.

59(60) Fore tarsi 1-segmented, scalpel-shaped. Rostrum short, at most 2-segmented, concealed under the head. Fore legs inserted near posterior margin of prosternum. ..... **CORIXIDAE Leach**

60(59) Fore tarsi never scalpel-shaped. Rostrum free, at least 3-segmented.

61(68) Ocelli wanting.

62(67) Fore coxae inserted at fore margin or about middle of prosternum. Body usually depressed above.

63(66) Middle and hind tarsi practically two-segmented (or segment 1 extremely short). Antennae 4-segmented. Abdomen without long respiratory tube.

64(65) Fore tibiae set with spines. ..... **NAUCORIDAE Fall.**

65(64) Fore tibiae flattened and set with hairs. . **BELOSTOMATIDAE Leach**

66(63) Middle and hind tarsi 1-segmented. Antennae 3-segmented. Abdomen with long, respiratory tube. ..... **NEPIDAE Leach**

67(62) Fore coxae inserted at posterior margin of prosternum. Cross-section of body about circular, not flattened. ..... **NOTONECTIDAE Leach**

68(61) Two ocelli present.

69(70) Legs simple. Antennae protruding. Eyes reniform. Rostrum 4-segmented. ..... **OCHTERIDAE Kirk.**

70(69) Fore legs prehensible. Eyes protruding. Antennae concealed. .... **MONONYCHIDAE Fieb.**

1. Family CYDNIDAE Billb.

Key to genera

1 (2) Scutellum strongly convex, covering nearly the whole abdomen. Surface metallic, bronze. ..... **Thyreocoris Schr.**

2 (1) Scutellum smaller. Body in most cases non-metallic.

3(16) Fore tibiae spatuliform, widened apically, more or less flattened, margins and inferior surface spiny.

4 (5) Clypeus pointed, wholly and broadly enclosed by the frontal processes. Scutellum hardly as long as broad at base. Large form. .... **Brachypelta A.S.**

5 (4) Clypeus not wholly enclosed.

6(13) Fore margin of head without spines, only set with hairs.

7(12) Fore margin of pronotum deeply excavated. Spines on hind tibiae longer.
8 (9) Hind femora with pre-apical tooth. Head and sides of pronotum with rigid bristles. Large form (6.5-8.5 mm.). ... **Macroscytus Fieb.**
9 (8) Hind femora unarmed. Head and pronotum provided with hairs only.
10(11) Black, small, depressed, elongate form. ..... **Geotomus M.R.**
11(10) Yellowish-brown, broadly oval, convex form. Very long setae at sides of pronotum and elytra. ..... **Putonisca Horv.**
12 (7) Fore margin of pronotum not deeply excavated. Spines on hind tibiae not longer than width of tibiae. Black. ..... **Amaurocoris Stal.**
13 (6) Fore margin of head with a submarginal corona of spines.
14(15) Fore margin of pronotum concave. Body strongly convex. .... **Byrsinus Fieb.**
15(14) Fore margin of pronotum angularly excavated, straight about middle. ..... **Cydnus F.**
16 (3) Fore tibiae prismatically incrassate towards apex, not flattened.
17(20) Mesosternum with median carina, the latter sometimes situated in longitudinal groove. Surface partly metallic bronze or blue.
18(19) Rostrum attaining middle of mesosternum. Surface with bronze shine, elytra partly yellowish. ..... **Crocistethus Fieb.**
19(18) Rostrum attaining end of metasternum. The only Egyptian species metallic blue, with fine white margin. ..... **Sehirus A.S.**
20(17) Mesosternum with longitudinal groove only. Smaller, depressed forms, somewhat elongate, surface dull. ..... **Ochetostethus Fieb.**

Thyreocoris scarabaeoides (L.).

Supposed to be distributed over North Africa (2). No record from Egypt.

Byrsinus Fieb.

1 (2) The whole body ferrugineous. Head smooth, clypeus parallel-sided. Middle and hind tibiae with both, spines and long setae, as well. ..... **fossor (M.R.)**
2 (1) Body brown, anteriorly, hemielytra ochrous. Clypeus narrowed towards apex. Middle and hind tibiae with spines only. .... **albipennis (Costa)**

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(2) Species recorded by Oshanin from North Africa must not necessarily occur in Egypt. First of all, French Entomologists use the term « Afrique du Nord » for the French part of North Africa only, and not in a geographical sense. This is evident, for instance, from Vidal's work on the Pentatomidae (see literature index) where many Egyptian species are omitted. Secondly, we have to emphasize that the Mediterranean part of Egypt differs somewhat climatically from Algeria, Tunisia or Morocco, being practically devoid of higher shrubs and trees, thus many insects inhabiting the western and central part of North Africa do not find living conditions in Egypt.

Byrsinus fossor (M.R.).

Gebel Asfar, on sand dunes under *Gramineae* in the sand (IV) ([3]).

Byrsinus albipennis (Costa).

In the sand under *Panicum* and other *Gramineae* (VIII-II). Border of deserts; Fayoum, Kerdasa, Matrouh.

Cydnus F. (Aethus auct.)

1 (6) Larger, mature specimens black, surface much shining. Venter not clothed with long setae.
2 (3) Vertex about two and one-half times as broad as the large, protruding eyes. Apex of scutellum slender, evenly rounded. ..... **macrophthalmus E. Wagn.**
3 (2) Vertex at least four times as broad as the small eye. Apex of scutellum broad, somewhat obtuse-angled.
4 (5) Clypeus nearly enclosed by the frontal processes. Vertex nearly five times as broad as the eye. Sides of scutellum straight before apex. ..... **hispidulus Klug**
5 (4) Clypeus broad at tip. Vertex about 4.1 times as broad as the eye. Sides of scutellum slightly concave anterior to apex. ..... **pilosus H.S.**
6 (1) Smaller species, length not exceeding 3.5 mm. Sternites clothed with long setae.
7 (8) Brown to dark brown. Elytra less shining. Body somewhat widened posteriorly. ..... **pilosus Klug**
8 (7) Mature specimens black. Punctuation finer, surface shining. ..... **cf. flavicornis F.**

Cydnus hispidulus Klug.

Delta and deserts, on the ground, under detritus, the whole year round, but not common. Giza Province, Canal Zone. At the lamp, too.

Cydnus pilosus H.S.

Sinai (Bodenheimer's list), probably confused with the foregoing or following species.

Cydnus macrophthalmus E. Wagner.

Meadi (V). Gebel Elba (I).

Cydnus pilosulus Klug.

Common in the sand under plants in desert valleys, especially under *Zygophyllum, Haloxylon, Panicum turgidum.* Attracted by the lamp. All over Egypt, also in Sinai and at the Red Sea Coast. All the year.

([3]) Roman figures between brackets (I-XII) indicate the months when the insects were collected or observed, e.g. (XI-II) = from November to February.

(Cydnus flavicornis (F.)).

Recorded from Sinai (Ain Musa) by Reuter (1891) and Royer (1914). Doubtful.

(Cydnus pallipennis Dall.).

Recorded (doubtfully) from Egypt, by Oshanin (1912).

Putonisca pallida (Put.).

Upper Egypt, Sinai, rare (I-IV, V, IX).

Macroscytus brunneus (F.).

All over Egypt, practically all the year. Common in the sand, under grasses or stones. At the lamp. Very common (II-III) in the Elba mountains. Sinai.

Geotomus spec. nov.

Common everywhere, particularly at the artificial light. Under detritus and halfa grass or *Tamarix* (I, V-XII). Southermost record : Assiout. Was formerly erroneously identified with *elongatus* (H.S.) and *pygmaeus* Dall.

Brachypelta aterrima (Forst.).

Less common than the former; on the ground under detritus, between grasses, under stones; chiefly in the cultivated part of the country. All the year. Southermost record : Assiout.

Amaurocoris curtus (Brullé).

Uncommon, in the sand under shrubs, sometimes at the lamp. Records: Meadi (VI), Sinai (IV), Gebel Elba (I).

Crocistethus waltli (Fieb.).

North Sinai (V), coll. Alfieri.

Sehirus melanopterus (H.S.).

Common, often in clusters under bark of trees (olive, grape-vine) or under stones. In great numbers in the olive groves at Borg-el-Arab and Gianaclis' vineyards. More in the north and in Sinai, rarer around Cairo and in Giza Province. All the year round, larvae from May onwards. It is suspected as doing harm to olives.

Ochetostethus Fieb.

1 (2) Apex of scutellum broadly rounded, attaining level of hind angles of corium. (Not recorded from Egypt). ..... **cf. pygmaeus (Ramb.)**

2 (1) Apex of scutellum slender, narrowly rounded. Length 4-4.5 mm.

3 (4) Corium partly yellowish. Head broader and shorter, with eyes strongly transverse. ..... **brachyscytus Reut.**

4 (3) Corium dark brown to blackish. Head less broad, eyes less strongly transverse. ..... **nanus (H.S.)**

Ochetostethus brachyscytus Reut.

At the base of *Gramineae* and other plants (e.g. *Artemisia*), rather rare but widely distributed, also in the desert, the oases and in Sinai (II-V).

Ochetostethus nanus (H.S.).

Like the foregoing species.

2. Family PLATASPIDAE Dall.

Only genus : *Coptosoma* Lap.

Coptosoma sandahli Reut.

This interesting species was described by Reuter (1881) and seems to be rather rare or confined to an uncommon plant. Length 2 (male) to 2.4 (female) mm. It was found at Asswan (cf. Pic, 1909; in coll. Museum Stockholm and Vienna).

3. Family PENTATOMIDAE Leach

Key to subfamilies.

1 (4) Scutellum (except in *Putonia*) very large, reaching apex of abdomen, covering clavus and a large portion of the corium and the membrane.

2 (3) Vena subcostalis and medialis of wing closely approximated, parallel. Hamus nearly always wanting. Frenum wanting or very short. ..... **Graphosominae Put.**

3 (2) Vena subcostalis and medialis of wing distant from each other. Hamus present. Frenum wanting. ..... **Scutellerinae Lap.**

4 (1) Scutellum not reaching apex of abdomen, triangular, leaving clavus, corium and membrane uncovered.

5 (6) Scutellum not reaching middle of dorsum of abdomen, apex broad; membrane very large. ..... **Dinidorinae Stal**

6 (5) Scutellum attaining at least middle of dorsum of abdomen, if not, apex slender and frenum long.

7 (8) Rostrum not surpassing fore coxae, joint 1 very short. ..... **Phyllocephalinae Dall.**

8 (7) Rostrum surpassing fore coxae, joint 1 long.

9(10) Rostrum stout, incrassate, particularly segments 1 and 2; joint 1 not enclosed in the rostral furrow, the latter hardly attaining middle of head. ..... **Asopinae Dall.**

10 (9) Rostrum slender, joint 1 embedded in the rostral furrow, the latter occupying the whole under side of the head. ... **Pentatominae Stal**

Key to genera (4)

1 (2) Antennae 4-segmented. Head and prothorax furnished with spines. Scutellum not attaining more than half of abdomen. **Phricodus Spin.**

(4) In this key we purposely omitted the subfamilies in order to facilitate identification of genera.

2 (1) Antennae 5-segmented.

3(32) Scutellum occupying the whole dorsum, corium visible somewhat only at base.

4(17) Base of scutellum broader than hind margin of the roughly hexagonal pronotum.

5 (6) Body blue or green metallic, strongly convex, with round orange dots. ..... **Callidea Burm.**

6 (5) Body non-metallic, without red dots.

7 (8) Median groove of meso- and metasternum bordered on either side by an elevated keel. Large form (14 mm.), ferrugineous, with two yellow spots in posterior third of scutellum. Body strongly narrowed posteriorly. ..... **cf. Solenostethium Spin.**

8 (7) Longitudinal furrow of sterna not bordered by high keels. Body not subacute posteriorly.

9(12) Head broader than long, semicircularly rounded in front, antennal cavities not covered by cheeks. Segments 2 and 3 of rostrum rather short and stout. More or less densely pubescent forms.

10(11) Body somewhat elongate. Pronotum square in outline, with a transverse depression. ..... **Irochrotus A.S.**

11(10) Body more roundish. Pronotum trapezoidal in outline, without transverse depression. ..... **Odontoscelis Lap.**

12 (9) Head longer than broad, triangular or square. Cheeks covering antennal cavities.

13(14) Elongate form, with short, dense, grey tomentum. **Alphocoris Germ.**

14(13) Roundish or elongate, in the latter case without grey pubescence.

15(16) Orifices of odoriferous glands inconspicuous. Scutellum more or less produced into a rounded process. ..... **Odontotarsus Lap.**

16(15) Orifices conspicuous. Pronotum scarcely broader than hemielytra, sides somewhat concave behind fore angles. ..... **Psacasta Germ.**

17 (4) Scutellum not or only slightly broader than base of pronotum, corium more broadly visible.

18(19) Small, green or yellowish species, strongly convex, with dorsal hump or carina on scutellum. Orifices indistinct. Venter with tubercle at base. ..... **Tarisa A.S.**

19(18) Scutellum without dorsal hump. Not green or much less convex.

20(21) Prosternum in front of coxae with a forwardly directed tooth. Angles of prothorax rather bluntly rounded. ..... **Sternodontus M.R.**

21(20) Prosternum without such teeth.

22(25) Angles of prothorax protruding, pointed, or only narrowly rounded.

23(24) Outline of body triangular. Yellow form, having numerous dark, longitudinal striae. ..... **Ancyrosoma A.S.**

24(23) Body not so strongly narrowed posteriorly, not exactly triangular. ..... **Trigonosoma Lap.**

25(22) Angles of pronotum not strongly pointed, not much protruding.

26(27) Body with red and black longitudinal stripes. Large forms of about 10 mm. length. ..... **Graphosoma Lap.**

27(26) Not striate with red and black. Smaller insects.

28(31) Fore angles of prothorax without sharp spine or process.

a (b) Small forms, not exceeding 6 mm.

29(30) Body with yellow and brown longitudinal lines, without elevated transverse wrinkles. Scutellum narrow, attaining apex of abdomen. ..... **Tholagmus Stal**

30(29) Body grey-brown or greyish yellow. Pronotum and scutellum with elevated transverse folds or wrinkles. ..... **Leprosoma Bär.**

b (a) Larger insects, 9-13 mm.; brown or grey to black or mottled. .... **Eurygaster Lap.**

31(28) Fore angles of prothorax produced into a sharp tooth. Dark grey form, with eyes much protruding. Dorsal surface little convex. .... **Scotinophara Stal**

32 (3) Scutellum not attaining apex of abdomen, membrane well visible.

33(76) Rostrum slender or moderately stout.

34(37) Large black or blackish brown forms.

35(36) Connexivum serrate, with fine teeth. Largest form. ..... **Mustha A.S.**

36(35) Connexivum not serrate. Rostrum short, reaching middle of mesosternum. ..... **Aspongopus Lap.**

37(34) Not blackish; or small forms. Lateral margin of abdomen not furnished with fine teeth.

38(43) Sides of head, pronotum and corium lamelliform, sharp-edged.

39(42) Margin of head with spines or stiff bristles. Spines of tibiae longer than width of tibiae.

40(41) Segment 1 of hind tarsi about twice as long as segments 2 and 3 combined. ..... **Orocephalus M.R.**

41(40) Segment 1 of hind tarsi as long as segments 2 and 3 combined. .... **Menaccarus H.S.**

42(39) Margin of head without spines. Tibiae with short spines. .... **Sciocoris Fall.**

43(38) Sides of head and pronotum not lamelliform, with blunt edges.

44(45) Comparatively very slender forms, yellowish to greenish, suggesting certain Coreids. ..... **Mecidea Dall.**

45(44) Not very slender.

46(49) Mesosternum with median longitudinal groove. Yellow, somewhat elongate, longitudinally brownish striate forms with pointed head.

47(48) Body strongly convex, dorsally and ventrally. Dorsal surface with alternating yellow and brownish stripes. Angles of pronotum little protruding. ..... **Aelia F.**

48(47) Body little convex on dorsum. Dorsal side nearly uniformly ferrugineous. Angles of pronotum strongly protruding. ..... **Diploxys A.S.**

49(46) Mesosternum with median carina which may be situated in a longitudinal groove.

50(57) Abdominal sternite II with a hump or a more or less long spine or thorn at anterior margin.

51(56) Sternite II with a forwardly directed spine.

52(53) Spine on base of abdomen long, reaching fore coxae. Length 7-8 mm. ..... **Pausias Jak.**

53(52) Spine shorter, attaining middle coxae.

54(55) Small form, length about 6 mm.; green with red. .... **Anchesmus Stal**

55(54) Larger, length 9-10 mm., pinkish or yellowish brown. .... **Piezodorus Fieb.**

56(51) Sternite II with a blunt hump. Large, usually *green* species. .... **Nezara A.S.**

57(50) Sternite II *without* spine or hump-like elevation at fore margin.

58(63) Orifices of sternal glands inconspicuous. Usually partly metallic species, with red or yellow markings.

59(62) Frontal processes narrow, clypeus broadly free. Eyes protruding.

60(61) Pronotum with deep transverse impressions, fore and lateral margins thickened. (On *Capparis*) ..... **Stenozygum Fieb.**

61(60) Pronotum with slight impressions, without callosities. .. **Bagrada Stal**

62(59) Frontal processes broad, at least partly enclosing clypeus. Metallic blue or green, with red, orange or yellow markings. .. **Eurydema Lap.**

63(58) Orifices of odoriferous glands conspicuous. Non-metallic forms.

64(65) Length 5-6 mm., yellowish-brown. Scutellum attaining apex of corium. Body rather flattened, with callosities on pronotum and scutellum. ..... **Putonia Stal**

65(64) Not these characters combined.

66(67) Orifices of glands not prolonged into a furrow. Head nearly square in front. ..... **Eusarcoris Hahn**

67(66) Orifices prolonged into a narrow groove.

68(69) Dorsal surface rather densely clothed with fine raised hairs. .... **Dolycoris M.R.**

69(68) Dorsal surface not with dense, raised pubescence.

70(73) General colour green.

71(72) Shortly built, strongly convex, with yellowish-white markings on scutellum. ..... **Chroantha Stal**

72(71) More elongate, more flattened forms. Scutellum yellow at apex only, sometimes with small median white dot at base. **Brachynema Muls.**

73(70) Not green.

74(75) Lateral margin of pronotum not sharp, anteriorly. ..... **Codophila M.R.**

75(74) Sides of pronotum all along with sharp, somewhat elevated margin. ..... **Carpocoris Klt.**

76(33) Rostrum incrassate, very stout.

77(78) Metallic blue or green. Length 5-6 mm. ..... **Zicrona A.S.**

78(77) Non-metallic. Larger.

79(82) Frontal processes not greatly surpassing clypeus, and not pointed.

80(81) Angles of pronotum sharply pointed, spiniform. ... **Andrallus Bergr.**

81(80) Angles of pronotum obtuse. ..... **Cyclopelta A.S.**

82(79) Frontal processes pointed, far surpassing clypeus. Large forms.

83(84) Head triangular, pointed. Elongate, flattened form, with two longitudinal pale dorsal stripes. ..... **Schizops Spin.**

84(83) Broad and strongly convex form of yellowish-brown colour, without longitudinal lines. Head somewhat rounded in front. Ethiopic. ..... **Phyllocephala Lap.**

Subfam. Scutellerinae Lap.

Callidea duodecimpunctata (F.).

Common in March on *Phyllanthus rotundifolius* Klein, in the valleys of the Elba mountains. Ethiopic element (leg. H. Priesner).

Odontoscelis Lap.

1 (4) Dorsal surface of body with dense, felt-like pubescence.

2 (3) Dorsum and ventral side of body without silvery or whitish pubescence. Large species (7-9 mm.), blackish, with small yellow markings. Antennae black, joint 2 about 1.5 times as long as 3. **fuliginosa (L.)**

3 (2) At least prothorax and ventral surface with partly silvery pubescence. Smaller (4-6 mm.), yellowish-brown, with dark markings; pronotum and scutellum usually with yellow longitudinal lines; male much smaller than female, with yellow lateral bands on scutellum, in addition. Antennae at least at base yellowish, joint 2 scarcely longer than 3. ..... **dorsalis (F.)**

4 (1) Surface with very fine, raised pubescence. Dark, small, somewhat elongate species, without distinct yellow markings. Length 2.5-4.75 mm.

5 (6) Anterior angles of pronotum surpassing eyes. ..... **cf. hispidula Jak.**

6 (5) Anterior angles of pronotum not surpassing eyes. ... **tomentosa Germ.**

Odontoscelis fuliginosa (L.).

In summer and winter in the sand under halfa grass (*Imperata cylindrica* and *Eragrostis bipinnata*), all over the Delta, particularly near the deserts. All the year.

Odontoscelis dorsalis (F.).

As common as *fuliginosa*, at the same localities and equally widely distributed. — The females were erroneously considered f. *litura* F. of the former species, by Bergevin. — The form considered typical (v. Stichel, p. 13) is the male; f. *deserta* Stich., f. *signata* and f. *lineola* Ramb. are females.

Odontoscelis tomentosa (Germ.).

Helouan (Wadi Hof) in January and August collected by Schatzmayr, Koch and Wittmer (cf. K. Schmidt, *Bull. Soc. Fouad I d'Entomologie*, XXII, 1938, pp. 24-27); specimens formerly identified as *hispidula* Jak. (also recorded in Oshanin's catalogue) have obviously to be referred to this species. It was known to us from the desert valleys east of Cairo and Helouan (I-III, V-VIII) and also occurs in the coastal zone (gulf of Suez). It is not common, and may be found under stones and *Zygophyllum coccineum* or *Zilla spinosa*.

Irochrotus montandoni Schout.

Uncommon under halfa grass (VI-I), Marg, Abu Roash, Mansuria, Kerdasa, Helouan.

Alphocoris larinoides Germ.

Everywhere in the valleys of the Libyan and Arabian deserts, south to Gebel Elba, not rare on *Panicum turgidum* and *Pennisetum dichotomum*, practically all the year round, larvae in III, VII and XII.

Odontotarsus Lap.

1 (6) Apex of scutellum considerably surpassing abdomen.
2 (3) Humeral angles of pronotum rounded. Apical prolongation of scutellum longer. ..... **caudatus (Burm.)**
3 (2) Humeral angles of pronotum conspicuous, protruding or pointed. Apical prolongation of scutellum shorter.
4 (5) Lateral margins of head in front of eyes straight. Inferior surface of body yellow, sometimes with dark longitudinal bands. Humeral angles of pronotum less strongly protruding. ..... **intermedius Horv.**
5 (4) Lateral margins of head slightly concave in front of eyes. Inferior face of body nearly wholly yellow. Humeral angles of pronotum more strongly protruding. ..... **humeralis Horv.**

6 (1) Apex of scutellum little produced, not or little surpassing apex of abdomen.

7 (8) Apical prolongation of scutellum narrower than vertex; the two lateral bands angular, interiorly. Anterior lobes of genital segment of female straight posteriorly, rectangular interiorly, not surrounding the median part. ..... **robustus Jak.**

8 (7) Apical prolongation of scutellum as broad as vertex; the two posterior lateral bands only slightly curved, interiorly. Anterior genital lobes of female rounded posteriorly, internal apical angle blunt, partly surrounding the median piece.

9(14) Posterior angles of segments of connexivum not or little protruding. Sides of abdomen near stigmata without tubercles or oblique elevations. The two posterior marginal bands of the scutellum more or less distinct, but not darkened.

10(13) Hind angles of connexival segments slightly protruding. Venter margined.

11(12) Posterior portion of pronotum and scutellum evenly and densely punctured, intervals raised. Scutellum with subbasal calli yellow. ..... **rugicollis Jak.**

12(11) Pronotum as in the former, punctuation of the scutellum less dense, and the intervals not raised. Yellow spots, but no calli on scutellum. ..... **concinnus Horv.**

13(10) Hind angles of segments of connexivum not protruding. Venter not bordered laterally. Body colour rufous (in f. *irrorata* Horv. colour dirty yellowish, and longitudinal bands little pronounced). ..... **rufescens Fieb.**

14 (9) Posterior angles of connexivum distinctly protruding. Sides of abdomen near stigmata with oblique elevation in the male, or with a tubercle in the female sex. The two posterior marginal bands of the scutellum well developed, darkened interiorly.

15(16) Pronotum and scutellum densely punctured, intervals raised. The two basal bands of the scutellum shortened and not united with the two lateral, posterior bands. ..... **horvathi Put.**

16(15) Pronotum and scutellum less densely punctured, intervals not elevated. The two secondary basal bands of the scutellum fused with the two lateral posterior bands. ..... **freyi Put.**

Odontotarsus caudatus (Burm.).

The most common and most widely distributed species in this country. Under herbs and grasses, on spikes of *Gramineae*, on flowers (e.g. *Umbelliferae*), *Zilla spinosa*, under *Zygophyllum*, etc., in the cultivated area and in the deserts (I-III; VII-XII).

Odonototarsus robustus Jak.

Recorded from Egypt (Oshanin 1912). Unknown from Egyptian collections.

Odontotarsus horvathi Put.

Specimens from Abuseer and Hammam (III-V), leg. A. Rabinovitch (coll. A. Alfieri); det. K. Schmidt.

Odontotarsus concinnus Horv.

On grasses in the Wadi Ibtadi (Galala) and Wadi Hof (IV-V), det. K. Schmidt.

Odontotarsus rugicollis Jak. f. callosa Horv.

A specimen from (V) Massara (coll. Alfieri, det. Horváth).

Odontotarsus rufescens Fieb. f. irrorata Horv.

Recorded from Egypt (Oshanin 1912).

Odontotarsus humeralis Horv.

A specimen from Siouf (VI) in the collection of the Ministry of Agriculture (det. Schmidt).

Odontotarsus freyi Put.

Recorded from Egypt (Oshanin 1912).

Odontotarsus intermedius Horv.

Uncommon, chiefly on *Gramineae*. Cairo region, Giza Province (V-VIII); det. K. Schmidt.

Psacasta marmottani Put.

More in the cultivated zones or the borders of the desert, on waste land, fallows; in the halfa formation, less in the northern steppe (Abukir), our records from (V-I); det. by H. Lindberg and K. Schmidt.

Eurygaster maura (L.).

Sinai (Oueli-Abu-Taleb, II-III), according to Royer (1914).

Subfam. Graphosominae Put.

Tarisa A.S.

1 (2) Scutellum with a conspicuous dorsal hump, showing, in lateral aspect, a cavity at the declivous part of the scutellum. .... **camelus Reut.**

2 (1) Scutellum with strong dorsal keel or small tubercle which is scarcely concave at the declivous portion.

3 (4) Surface shining, pale green. Legs green or yellowish, femora sometimes orange. Declivous part of scutellar keel (tubercle) one-third the length of declivous part of scutellum. ..... **subspinosa (Germ.).**

4 (3) Surface dull, darker green. Femora at least partly blackish, tibiae brownish with a pale median ring. Declivous part of scutellar keel one-fourth of length of declivous portion of scutellum. ..... **cf. dimidiatipes Put.**

Tarisa camelus Reut.

Uncommon in the valleys of the Arabian desert, on *Haloxylon schweinfurthii* (III-VI, X); Wadi Feirân, Ain Mousa (Sinai); det. K. Schmidt.

Tarisa subspinosa (Germ.).

In the cultivated area (e.g. Fayoum), on *Tamarix* (IV, V, IX).

Trigonosoma Lap. (Ventocoris Hhn.)

1 (2) Head shorter than (with eyes) broad. Rostrum surpassing hind coxae. Second abdominal segment with longitudinal groove. (Subg. *Trigonosoma* s.str.). Not yet recorded from Egypt.

2 (1) Head about as long as broad (with eyes). Rostrum not surpassing hind coxae. Second sternite without groove.

3(10) Large, strongly convex species. Margins of scutellum not parallel near base. (Subg. *Selenodera* Horv.).

4 (5) Angles of pronotum blunt. ..... **obtusum Horv.**

5 (4) Angles of pronotum produced.

6 (7) Pronotum brownish, with a broad yellow transverse line between the angles; the latter directed somewhat obliquely forward. Scutellum as long as broad or somewhat longer than broad. Antennal joint 3 comparatively short. ..... **fischeri (H.S.)**

7 (6) Pronotum without yellow transverse stripe between the angles. Colour testaceous to brown, sometimes angles of pronotum blackish.

8 (9) Angles of pronotum more strongly produced, slightly directed obliquely forward, black posteriorly. Pronotum with three transverse impressions anteriorly. Considerably narrower than *obesus*. ..... **falcatum (Cyrr.)**

9 (8) Angles of pronotum not at all forwardly directed. Body wholly brownish yellow, or angles of pronotum with apices black (f. *humeralis* Horv.). ..... **obesum (Stal)**

10 (3) Small, somewhat flattened form. Prothoracic processes well developed, rounded at apex. Margins of scutellum parallel at base. (Subg. *Paraselenodera* Schout.). ..... **modestum Jak. var. martini Horv.**

Trigonosoma obtusum Horv.

Described from Egypt (Tel-el-Kebir, X); not in Egyptian collections.

Trigonosoma fischeri (H.S.).

Not rare, under *Panicum, Zygophullum, Trigonella,* particularly in

the desert, from Alexandria up to Kena (Upper Egypt), all the year Canal Zone, Sinai.

Trigonosoma falcatum (Gyrr.).

A single specimen from Ikingi (Mariout) (VIII), in coll. Alfieri. According to Walker, Royer and Bodenheimer occurring on Mount Sinai. Horváth described some weak varieties of which the most remarkable one, f. *achivum* Horv., has prothoracic horns blunt, short, the width between the horns being shorter than the length of the body; colour testaceous.

Trigonosoma obesum (Stal).

Sometimes in numbers on *Zilla spinosa*, in the desert valleys, on waste land between cultivations near the desert, all the year. All the Delta, Canal Zone, Upper Egypt and Sinai. No records from the northern coast. *T. obesum* f. *humeralis* Horv. is common.

Trigonosoma modestum Jak. var. martini Horv.

Rare. Abu Rowash, Mansuria, Wadi Morrah (I-III), under halfa grass; a specimen (coll. Alfieri) was found in the stomach of the tawny pipit (*Anthus campestris*).

Putonia torrida Stal.

Locally rather common under *Panicum turgidum*, *Imperata cylindrica*, *Zygophyllum coccineum* and *Ambrosia maritima*, at the borders of the desert (VII-II). All over Egypt.

Leprosoma reticulatum (H.S.).

Rare. Under *Panicum turgidum*. Pyramids of Giza, Kafr Hakeem, Ikingi (Mariout) (VII-X, XII).

(Leprosoma inconspicuum Bär.).

Bärensprung who mentions (1859) a specimen from Egypt has no doubt confused it with the above species.

Sternodontus obtusus M.R.

Recorded from Egypt (Oshanin 1912), but not represented in any Egyptian collection.

Ancyrosoma albolineatum (F.) (leucogrammum Gmel.).

Everywhere in the cultivated areas, on waste land (e.g. on *Umbelliferae*) and in the desert, but only locally more numerous, presumably all the year round. *A. affine* Westw. described from Egypt was considered by Horváth a variety of *albolineatum* (F.); it is characterized in having sides of scutellum nearly straight, not concave.

Tholagmus chobauti Put.

A desert species that may locally be found in great numbers; IV-X, always (with larvae (X)) on *Pithyranthus tortuosus* (*Umbelliferae*).

Graphosoma Lap.

1 (2) Pronotum with two black marginal bands and ten black spots. .... **semipunctatum (F.)**

2 (1) Pronotum with six black longitudinal bands. ..... **lineatum (L.)**

Graphosoma semipunctatum (F.).

Rare in Egypt. In Alfieri's collection a specimen from El-Kantara (V).

Graphosoma lineatum (L.).

Recorded from Egypt (see Horváth 1909, and Oshanin 1912).

Scotinophara sicula (Costa).

Rare species, occurring near the deserts, on the ground (I, III). Localities : Bedreshein, Gebel Asfar, Marg.

Subfam. Pentatominae Stal

Phricodus aegyptiacus Izzard.

Sometimes in numbers (with larvae (V)) on *Lavandula coronopifolia*, but particularly on *Stachys aegyptiaca*. Wadi Hof near Helouan (V-X). The only palaearctic member of this genus.

Mustha A.S.

1 (2) Lateral abdominal spines, on connexivum, fine, numerous. Black, with apex of scutellum yellowish. Hind tibiae curved. **morgani Horv.**

2 (1) Lateral abdominal spines of connexivum less numerous, stouter. Apex of scutellum margined with yellow. Hind tibiae nearly straight. ... . **cf. spinosula (Lef.)**

Mustha morgani Horv.

Uncommon (II, IV, IX, XI); Sinai (Umm Arat, Gindeli, Kassab, leg. Kaiser). Rabinovitch found the species in Middle Egypt (Wadi Geraui near Helouan, Wadi Rishrash) near the roots of *Anabasis articulata*. It is an Iranian element.

(Mustha spinosula (Lef.)).

Bodenheimer records this species from Sinai. Identification most likely incorrect.

Mecidea Dall.

1 (2) Antennal joint 2 little or not incrassate, 3 distinctly shorter than 4.

Pronotum not longer than broad at anterior margin. Less slender species. ..... **pallida Stal**

2 (1) Antennal 2 distinctly dilated at base, 3 nearly as long as 4. Pronotum longer than broad at anterior margin. Smaller, but more slender species. ..... **ingramsi China**

Mecidea pallida Stal.

On waste land, field borders, near the deserts, sometimes in numbers; on desert plants (e.g. *Zilla spinosa*) or barley and other *Gramineae*. *M. pallida* var. *virens* Vid. also occurs in Egypt.

Note : In the female, antennal joint 2 is twice to more than twice as long as joint 3, while it is little longer than 3, in the male.

Mecidea ingramsi China.

A desert species, uncommon. Meadi, Giza, Wadi Assiouti, Oasis Dakhla ; Sinai (Wadi Isla, El-Areesh) ; Gebel Elba. (III-V). May be caught at the lamp.

Orocephalus M.R. (Pododus A.S.)

1 (6) Antennal joint 2 distinctly longer than 3.

2 (5) Fore margin of head and lateral margins of prothorax and corium furnished with black spines, the latter being more numerous, at least on prothorax, than in *dohrnianus*. Colour darker, margins of pronotum and corium pale.

3 (4) Scutellum about as long as corium at exterior angles. Margin of pronotum with 19-20, that of exocorium with 11-12 spines. Outline of body oval. Sides of head less convex than in *dohrnianus* and *rotundatus* (Tunisia, Morocco) ..... **cf. jakovleffi (Reut.)**

4 (3) Scutellum somewhat shorter than corium at exterior angles. Margin of pronotum with 15-18, of corium with 8-9 spines. Outline of body more broadly oval, strongly rounded (Algeria, Tunisia). .... **cf. rotundatus Horv.**

5 (2) Fore margin of head and lateral margins of prothorax and corium with yellowish or fulvous spines which are less numerous, being 13-15 on prothorax (and 7-11 on corium). Varying in colour but generally paler. ..... **dohrnianus (M.R.)**

6 (1) Antennal 3 as long as 2. Pronotum with about 14, corium with about 7 dark spines. Scutellum less narrowed posteriorly, broadly rounded at apex, as long as corium. Broader than *dohrnianus*, and lateral margin of head more strongly incised in front of eyes. .... **dissimilis Horv.**

Orocephalus dohrnianus (M.R.).

Uncommon but everywhere; desert valleys, coastal regions, borders of

Delta cultivations, also Upper Egypt. In sand under shrubs and grasses (*Artemisia, Panicum turgidum*) and under stones; seems to prefer dunes (IV, VIII, IX-I). Sinai.

Orocephalus dissimilis Horv.

Rabinovitch found a specimen at Abu Roash (V); Horvath's type originated from Abukir, a specimen of the Entomological Society's collection from the same locality, and the Pyramids (I, V, VII).

(Orocephalus jakovleffi (Reut.)).

Lindberg gave this name to a specimen from Kerdasa (VIII) which we cannot distinguish from *dohrnianus* M.R.

Sciocoris Fall.

1 (2) Pale brownish yellow. Margin of head in front of eyes with a tooth-like projection. Apex of scutellum not attaining apex of corium. ... . **pallens Klug**

2 (1) Mature specimens not pale yellow. Margin of head without lateral tooth.

3 (8) Smaller species.

4 (5) Pronotum nearly three times as broad as long. Shortly built species, varying in colour. Apex of scutellum not attaining apex of corium. Head in front of eyes comparatively very broadly rounded. .... **conspurcatus Klug**

5 (4) Pronotum less strongly transverse. Apex of scutellum reaching apex of corium. Somewhat more elongate species.

6 (7) Margin of pronotum yellow, without dark punctures. Head broadly rounded in front. Body more slender. .....**angusticollis Put.**

7 (6) Margin of pronotum with dark punctuation extending to edge. Head more triangular, body more flattened, broader. Sides of head slightly concave in front of eyes, strongly narrowed towards apex. .... **scutellaris K. Schmidt**

8 (3) Larger species, length 6-7.5 mm. broad. Margin of pronotum not broadly yellow. Smaller specimens differ from *scutellaris* in having sides of head not concave in front of eyes. .... **helferi Fieb. var. major Klug**

Sciocoris conspurcatus Klug.

All over the country, the most common member of this genus; the whole year, particularly under *Zygophyllum*. Sinai.

Sciocoris pallens Klug.

On *Chenopodium* in Alexandria (ex Klug). Not found since.

Sciocoris angusticollis Put.

Hitherto found only in the desert valleys under shrubs. Uncommon, the whole year; det. K. Schmidt.

Sciocoris helferi Fieb. var. major Klug.

Cultivated areas and desert, under grasses and scrub, not rare, all the year. Southermost record : Wadi Assiouti.

(*Sciocoris umbrinus* Wolff, cited in Storey's list (1916) has to be referred to *helferi major* Klg.).

Sciocoris scutellaris K. Schmidt.

From Wadi Hoff, Ogret-el-Shekh, Wadi Ranga; Gebel Elba (III-VI). Under stones and at the base of desert shrubs.

Diploxys cordofana (Mayr).

Recorded from Egypt (Oshanin).

Aelia punctiventris Horv.

Not rare, from the Alexandria region all over the Delta to Beni-Suef and Fayoum; on canal banks, on fields (cereal crops, grasses and *Umbelliferae*), the whole year (cf. Horváth 1910; K. Schmidt 1939).

(Aelia klugi Hahn).

Recorded from Egypt (Oshanin, 1912), but most likely not occurring in this country.

Eusarcoris inconspicuous (H.S.).

All over the cultivated area, from the coastal regions (Alexandria, Fayed) to at least Assiout; in the oases Dakhla and Kharga and in the Sinai (in Bodenheimer's list as *helferi* Eichh.); common in the Delta on various low plants, on canal banks, waste land, orchards; less common in the desert (Wadi Rishrash). The species seems to prefer humid conditions. All the year. May also be seen at the light traps.

Var. *simplex* Put. : Calli at base of pronotum indistinct; var. *helferi* Fieb. has a yellow longitudinal band on the head. Both occur in Egypt.

Carpocoris Kiti.

1 (2) Margin of pronotum in front of pointed angles convex, behind them concave. Colour never reddish. Yellowish with brown punctuation. ... . **fuscispinus (Boh.)**

2 (1) Margin of pronotum nearly straight in front and behind of rounded or slightly pointed angles. Colour often reddish or purple. .... **pudicus (Poda)**

Carpocoris fuscispinus (Boh.).

Rare; only in the Mariout and probably Marmarica. Sinai (Gebel Katherine) (in coll. Alfieri).

C. fuscispinus mentioned in Storey's list has to be referred to *pudicus* (Poda).

Carpocoris pudicus (Poda).

Much varying in coloration and size. Everywhere in the Delta and the coastal planes, particularly on thistles on waste places, canal banks, borders of fields, orchards and sometimes also in the desert. Not so abundant as *Nezara viridula*. All the year.

Codophila M.R.

1 (2) Sides of pronotum strongly concave; pronotum anteriorly with four dark longitudinal spots. Scutellum with three dark basal spots. Base of antennae, at least in the female, yellowish or crimson. Smaller, on an average. ..... **varia (F.)**

2 (1) Sides of pronotum nearly straight; pronotum with complete dark longitudinal bands, which are often fused, posteriorly. Scutellar spots usually fused together. Antennae black. ..... **maculicollis (Dall.)**

Codophila varia (F.).

Uncommon. Distributed particularly over the Mediterranean parts of the country, but found south up to Menufia Province (IX, X).

Codophila maculicollis (Dall.).

All over the Delta, also in the Mediterranean region, and in Sinai; always on sandy places, at the border of the deserts, obviously bound to *Echinops spinosus*, where the larvae can be observed, too. All the year round. Much varying in general colour.

Dolycoris M.R.

1 (2) Genital segment of male, viewed laterally, forming two lobes the lower one of which protrudes more strongly than the top one; styli somewhat thickened apically. Head of equal length in both sexes. Antennal joint 1 with black spot, exteriorly. ..... **cf. baccarum (L.)**

2 (1) The lower one of the two lobes of the genital segment of the male, in lateral aspect, much less protruding than the dorsal lobe. Styli more slender at apex. Head of male generally longer than that of female. Antennal 1 rarely with a dark spot. ..... **numidicus Horv.**

Dolycoris baccarum (L.).

Recorded from Sinai by Bodenheimer.

Dolycoris numidicus Horv.

A specimen from Alexandria (leg. A. Carneri) was seen by K. Schmidt and doubtfully referred to this species (in coll. K. Schmidt).

Chroantha ornatula (H.S.).

Northern coast, Delta and Canal Zone, sometimes in the desert, occurring also in the oases and in Sinai. In Upper Egypt up to Assouan. On shrubs and trees (*Acacia nilotica, Sesbania aegyptiaca*) locally more numerous, normally uncommon (III-X).

Brachynema Muls.

1 (2) Elongate form, length 12-14 mm. Head longish, margin of pronotum unicolourously whitish. ..... **virens (Klug)**
2 (1) More shortly built species; length 8-11 mm. Head short. Pronotum just in front of hind angles with a black dot.
3 (4) Scutellum with a very small white dot in the middle of its base. Antennal joint 2 one-third longer than 3. ..... **venustulum Mont.**
4 (3) Scutellum without basal white dot. Antennal 2 slightly longer than 3. ..... **cinctum (F.)**

Brachynema virens (Klug).

Not rare, in the deserts and on the borders of the cultivations (III-VI). Lower and Upper Egypt, Sinai. We have no records from the north. The species is attracted by the lamp. In March, a specimen was found in the Libyan desert (Gebel Hameed), under a stone.

Brachynema venustulum Mont.

A specimen from Borg-el-Arab (VIII) (coll. Min. Agric.) we have to refer to this species.

Brachynema cinctum (F.).

Particularly in the Mediterranean Zone, but also recorded from Fayoum, and thus also in the Delta; Sinai; uncommon. On trees and lower plants (*Zygophyllum*, etc.), (III, VII-XII).

In f. *flavata* Horv. the parts of the body coloured red in the typical form are yellow; f. *splendida* Mont. is much more extensively coloured red than the typical form; f. *miniatula* Mont. is less vividly tinted with red than the foregoing form, and the legs are wholly green.

Eurydema Lap.

1 (2) Dorsum of abdomen red. Black spots on pronotum usually fused. Exocorium with small black spot. A black, broad cross-band over base of scutellum and corium. Legs usually dark ..... **ventrale Kiti (ornatum auct.)**
2 (1) Dorsum of abdomen black.
3 (4) Pronotum anteriorly with two, posteriorly with four (sometimes fused) dark spots. ..... **ornatum (L.) (festivum auct.)**

4 (3) Pronotum anteriorly with two broad dark spots. Surface of pronotum strongly rugose. ..... **rugulosum (Dhrn.)**

Eurydema ventrale Kltf.

We only saw a single specimen from Meadi (V), coll. Alfieri; this insect is certainly rare in Egypt.

Eurydema ornatum (L.).

On *Zilla spinosa* and garden *Cruciferae*, locally common, all the year The species varies considerably in colour, the pale parts being often yellowish instead of crimson (f. *picta* H.S.), and the dark markings varying in size. All over the country; in the oases Dakhla, Kharga and Siwa; Sinai.

Eurydema rugulosum (Dhrn.).

A specimen from Sinai (V) in coll. Alfieri.

Stenozygum coloratum (Klug).

All over the rocky desert (inclusive of Sinai) locally sometimes in large colonies, on *Capparis spinosa*, severely damaging the plants. The whole year, larvae observed in VI and VII.

Bagrada Stal (5)

1 (2) Scutellum longer than broad at base, rather narrow at middle, with faint percurrent median carina. Body elongate-oval. Calli lenticulares of pronotum pale, margined with black. Tibiae wholly pale. (Subgen. *Ayeshella* Horv.). ..... **cf. poecila Kl.** (Arabia)

2 (1) Scutellum without median carina, as long as or scarcely longer than broad at base. Body sometimes shortly oval. Calli lenticulares of pronotum black. Tibiae with two dark lines above.

3 (4) Scutellum with complete, pale median longitudinal line which is narrow and not truncate in front. Lateral margins of pronotum wholly reflexed. Scutellum somewhat longer than its basal width; frena surpassing middle of sides. (Subgen. *Bagrada* s.str.). .... **picta (F.)**

4 (3) The yellow apical portion of the scutellum broad and truncate in front. Lateral margins of pronotum not distinctly reflexed in posterior part. Scutellum about as long as broad at base, rather broad behind middle; frena not surpassing middle of scutellum. (Subgen. *Nitilia* M.R.).

5 (8) Body elongate-ovate.

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(5) A critical study of this genus is required, since Horvath laid much stress on the shape of the body, disregarding the fact that the sexes of at least several species differ greatly in this respect.

6 (7) Antennal joint 1 wholly black, 2 one-sixth longer than 3. Lateral margin of pronotum nearly wholly margined with black. Connexivum red, extreme base of segments black. ..... **royeri Horv.**

7 (6) Antennal 1 with white spot interiorly, joint 2 three-tenths longer than 3. Anterior lateral margin of pronotum only at fore angles with small black spot. Connexivum wholly pale. .... **cf. algirica Horv.** (Biskra)

8 (5) Body oval.

9(10) Body dorsally and ventrally predominantly yellow. Antennal joint 1 of male with interior yellow spot, the following joints fulvous. Punctuation of pronotum finer. Scutellum somewhat narrower. .... **(singularis Horv.)**

10 (9) Body black, with whitish, yellow or red markings. Antennae black, joint 1 seldom with white interior spot, or with brownish apical joints. Punctuation of pronotum coarse and somewhat rugose posteriorly. .

11(12) Scutellum at base with black, semi-circular spot that is divided medianly. Lateral margin of pronotum pale with black spot at fore angles. ..... **amoenula (Walk.)**

12(11) Black basal spot of scutellum transverse, not bipartite, surrounding the two red basal calli. Lateral margin of pronotum entirely black. ..... **deserticola Horv.**

The above key is based on Horváth's key (*Ann. Mus. Nat. Hung.*, XXX, 1936, p. 23), with the addition of some new distinguishing characters.

Bagrada picta (F.).

Only locally sometimes in numbers. Host plant unknown. Fayed, Giza Pyramids, Wadi Hof, Wadi Ibtadi, Oasis Dakhla (IV, V, IX). The varieties: *connectens* Horv., *hilaris* Burm. and *modesta* Horv. were not observed in Egypt, all specimens we were able to examine belonging to the typical form.

Bragada royeri Horv.

Horvath's description is obviously based on two female specimens only (from Sinai and Cairo; f. *picticollis* Horv. having a yellow cross-line near middle of pronotum). Common in the desert valleys on *Cleome arabica* and *Zilla spinosa*. Maksama, Kassasseen, Fayed, Meadi, Helouan (Wadi Digla, Wadi Gerawi, Wadi Hof). The whole year.

Note: The sexes differ not only in size, but also in the shape of the body, which is more or less elongate in the female, shortly oval in the male. The species varies greatly in the coloration of the body and the antennae (e.g. white spot on antennal joint 1 present or wanting in the female, terminal joints fulvous in the male).

(Bagrada singularis Horv.).

This species was described after a unique male specimen from Cairo. It is, as to our opinion, the male of *royeri* Horv.

Bagrada amoenula (Walk.).

Type specimen from Sinai (coll. British Museum).

Bagrada deserticola Horv.

Scarcely more than a variety of the former species. Horvath's type specimens are from the desert near Cairo.

To *deserticola* we are referring specimens of our collections from Helouan, Wadi Hof, Massaara, Sinai and Gebel Elba (XI-IV). Horvath's var. *lineata* has an abbreviated yellow transverse line on either side of posterior lobe of pronotum.

Nezara A.S.

1 (2) Large species, length 12-17 mm. Venter with median keel. Scutellum with three small yellowish dots at base; the f. *torquata* F. with fore margin of pronotum and anterior portion of head broadly yellowish white. ..... **viridula (L.)**

2 (1) Smaller, 7-12 mm. Venter without keel. Entirely green (or dull brown or pinkish), without pale dots at base of scutellum.

3 (4) Antennae greenish. Rostrum not surpassing hind coxae. Smaller, shortly built species. 7-10.5 mm. ..... **millierei M.R.**

4 (3) Antennal joint 3 (for the greater part), 4 and 5 reddish. Rostrum surpassing hind coxae. Larger, on an average, and more elongate, 8-12 mm. ..... **heegeri (Fieb).**

Nezara viridula (L.).

Everywhere the whole year round in the cultivated parts of Egypt, common, breeding on a variety of plants. Eggs are parasitized by *Microphanurus megacephalus* Ashm. (*Proctotrupidae*), a species that was successfully introduced from Egypt to Australia (cf. M. Kamal, *Bull. Soc. Roy. Ent. d'Egypte*, 1937, p. 175). The insect is not a serious pest in this country, most likely owing to the presence of the parasite.

Besides f. *torquata* F. (see key), there exist brownish (f. *hepatica* Horv.) and pinkish (f. *aurantiaca* Horv.) forms; both are winter forms.

Nezara millierei M.R.

Widely distributed, from the northern and eastern coast to Assouan and Gebel Elba, and also in the Sinai peninsula. On trees and shrubs. F. *rosea* Noual. is rare (Fayoum, XI, on *Tamarix*). The species may be found all the year, but is much less abundant than *viridula*, and thus of no economic importance.

Nezara heegeri (Fieb.).

Only locally in numbers. Cairo, Meadi, at the lamp (IV-XI); f. *rubescens* Noual. is characterized by its pinkish hue; f. *submarginata* Stal has reddish lateral margin of pronotum.

Piezodorus teretipes Stal (?).

Only known from the south, Wadi Assiouti (IV) and Assouan. The name was given by E. Wagner.

Pausias leprieuri Sign.

Widely distributed; we know it from the Delta, the Suez Canal Zone, the southern Nile valley, the northern coast, and also from Ouwenât. On trees and bushes, most likely all the year.

Anchesmus ruficornis (Stal).

Only locally more numerous, on *Cupressus*, *Tamarix* (I, IV, VII-XII). Nile Delta.

Subfam. Asopinae Dall.

Andrallus spinidens (F.).

Sinai (Wadi Gederât (V), coll. Alfieri).

Zicrona coerulea (L.).

A specimen from El-Kantara, 12.V.19 (coll. Alfieri).

Subfam. Dinidorinae Stal

Aspongopus viduatus (F.) f. unicolor H.S.

The colour of this form is uniformly black or brownish.

A pest of cucurbitaceous crops (*Citrullus vulgaris*), and in the desert on *Citrullus colocynthis*. Common in Upper Egypt, Nubia, and also in the Elba mountains and in Sinai. Only occasionally in the latitude of Cairo (desert valleys near Meadi), exceptionally in the north (Mersa Matrouh). All the year.

Cyclopelta funebris (F.).

Sinai (Bodenheimer's list, with ?).

Subfam. Phyllocephalinae Dall.

Schizops aegyptiaca (Lef.).

Fairly common in the Nile valley, always on halfa grass (*Imperata*, *Eragrostis*), all the year; larvae observed V-VI; southermost record : Shellal near Assouan. We never saw it in the desert.

Phyllocephala albicornis Horv.

A few specimens were collected in the Wadi Aideb (Gebel Elba) and

at Mersa Halaib at the Red Sea coast, on grasses (especially *Panicum turgidum*) in January. Sinai (IV). Ethiopic element.

4. Family COREIDAE

Key to genera ([6])

1(40) Orifices of odoriferous glands conspicuous, auriculate, situated near fore margin of metasternum and base of middle coxae. (*Coreinae* Stal, *Pseudophloeinae* Stal and *Alydinae* Stal) ([6]).

2 (3) Sides of abdominal segments lobiform, deeply incised. Body with long spines. Legs extremely slender. ..... **Phyllomorpha Lap.**

3 (2) Sides of abdomen not deeply incised between segments, not spiny.

4 (5) Body very slender, long, linear. Hemielytra reduced. Rostrum attaining hind margin of mesosternum. ..... **Prionotylus Fieb.**

5 (4) Not the above characters combined.

6(29) Head much narrower than pronotum.

7(18) Hind femora with one or several spines at posterior margin. Vertex without longitudinal groove.

8(11) Hind femora with one conspicuous spine, at the most. Antennal joint 2 shorter than half of joint 3.

9(10) Lateral margin of pronotum and head with spines and tubercles. ... . **Pseudophloeus Burm.**

10 (9) Lateral margin of pronotum smooth. Head and pronotum without humps or tubercles. Antennal joint 4 oviform, much shorter than 3. ..... **Bathysolen Fieb.**

11 (8) Hind femora with several spines.

12(13) Hind coxae closely approximated. ..... **Ceraleptus Costa**

13(12) Hind coxae far apart.

14(15) Posterior angles of pronotum at the sides of the scutellum produced into a spine. ..... **Coriomeris Westw.**

15(14) Posterior angles of pronotum not produced spine-like.

16(17) Fore femora with spines. Antennal 4 longer than 3. .... **Loxocnemis Fieb.**

17(16) Fore femora unarmed. Antennal 4 shorter than 3. .... **cf. Bothrostethus Fieb.**

18 (7) Hind femora unarmed. Head with more or less distinct longitudinal impression.

19(24) Antenniferous tubercle produced tooth-like, exteriorly.

([6]) For facilitating identification of the genera, the higher groups are not considered in this key.

20(21) Posterior angles of pronotum at both sides of scutellum produced into lobiform, pale process. ..... **Centrocoris Klti.**

21(20) Posterior angles of pronotum not produced in this manner.

22(23) Sides and posterior margin of pronotum nearly smooth. Antennae only about one-half as long as body, joint 1 oval. ... **Spathocera Stein.**

23(22) Sides and hind magin of pronotum spinulose. Antennae almost as long as the body, joint 1 sharp-edged, cylindrical. ..... **Cercinthus Stal**

24(19) Antenniferous tubercle exteriorly not produced into a tooth.

25(26) Head long, pointed, cheeks prolonged anteriorly. Body more slender, elongate-elliptical. ..... **Stenocephalus Latr.**

26(25) Head shorter, cheeks not prolonged anteriorly. Less elongate forms.

27(28) Connexivum little widened. Angles of pronotum sharply pointed, somewhat directed forward. ..... **Cletus Stal**

28(27) Connexivum strongly enlarged. Angles of pronotum little produced. ..... **Haploprocta Stal**

29 (6) Head large, as broad as pronotum or nearly so. Hind femora with teeth of varying size, at interior margin.

30(37) Hind tibiae more or less *curved*, without a row of spines at interior margin but with short, terminal spur.

31(34) Hind coxae closely approximated. Larger forms, 12-14 mm.

32(33) Eyes sessile. Ultimate antennal joint about as long as the two preceeding joints combined. ..... **Riptortus Stal**

33(32) Eyes pedicellate. Ultimate antennal joint much shorter than the two preceeding joints combined. ..... **Camptopus A.S.**

34(31) Hind coxae widely distant. Less elongate forms, length not over 10 mm.

35(36) Head very strongly constricted behind eyes. Orifices not extended into a long furrow. ..... **Sjoestedtina Dist.**

36(35) Head hardly constricted behind eyes. Orifices extended. .... **Tenosius Stal**

37(30) Hind tibiae straight or nearly so, with a row of spines within.

38(39) Hind femora distinctly shorter than hemielytra. Male with small tooth on hind femur. Segment 1 of hind tarsi scarcely longer than the two terminal segments combined. ..... **Nemausus Stal**

39(38) Hind femora as long as hemielytra, or nearly so. Male with stout pre-apical tooth on hind femur. Segment 1 of hind tarsi about twice as long as the two apical segments combined. ..... **Nariscus Stal**

40 (1) Orifices of odoriferous glands inconspicuous (*Corizinae* Stal).

41(42) Corium and clavus not transparent, veins little prominent. Membrane dark. Red and black species, suggesting *Spilostethus*. .... **Therapha A.S. (Corizus Fall.)**

42(41) Corium and clavus transparent, veins conspicuous. Membrane whitish.
43(48) Head short, with eyes much broader than long.
44(47) Hind angles of metasternum pointed or at least protruding, lobiform.
45(46) Thickened fore margin of pronotum smooth. ..... **Liorhyssus Stal.**
46(45) Thickened fore margin of pronotum punctured. .... **Rhopalus Schill.**
47(44) Hind angles of metasternum not protruding, rounded. ..... **Stictopleurus Stal**
48(43) Head elongate, longer than broad (inclusive of eyes) or about as long as broad.
49(50) Femora for the major part black, tibiae with blackish base and apex. Body stouter, elongate-ovate. Intermediate antennal joints stouter.... **Maccevethus Dall.**
50(49) Legs for the major part pale. Body slender, yellowish, yellow-brown or greenish. Antennae slender. ..... **Agraphopus Stal**

Subfam. Coreinae Stal

Cletus borealis Bl.

In numbers collected by M. Tewfik and H. Priesner in the Elba mountains, in I-III (det. W.E. China).

Haploprocta sulcicornis (F.).

On waste land, field borders, fallows, in the Delta and Canal Zone, Mariout, common, all the year.

Centrocoris Klti.

1 (2) Smaller species, length 7-8 mm. Clypeus without prominent spines. Posterior angles of prothorax rectangular. ..... **degener (Put.)**
2 (1) Larger, 9-10 mm.
3 (4) Clypeus with a series of spines. Body with brown markings. Posterior angles of prothorax pointed. ..... **variegatus Klti.**
4 (3) Clypeus and pronotum without spines. Colour uniformly testaceous. ..... **cf. marmottani (Put.)**

Centrocoris degener (Put.).

Rare. Fayoum, Ghobbet-el-Buss (VIII); det. K. Schmidt.

Centrocoris variegatus Klti.

Coastal area, north and east (Fayed), and Delta, not rare in autumn, on waste places, fallows, field borders, orchards, collected from III to XI.

(Centrocoris marmottani (Putt.)).

A specimen identified by Bergevin as *marmottani* is an immature example of *variegatus*.

Cercinthus lehmanni (Klti.).

On dry land, field borders, dunes. On *Gramineae*, under *Echium* on the dunes of the coastal plane and in the Delta, south to Giza Province. Sinai. Not rare, all the year round.

Spathocera lobata (H.S.).

Our specimens are from the Cairo region, Menufia Province and Giza, on and under halfa grass and other *Gramineae*, all the year.

Prionotylus brevicornis (Muls.).

Like the foregoing species, taken from Mansuriah to Helwan (VIII-I), on and under halfa grass.

Phyllomorpha Lap.

1 (4) Antennal joint 2 and base of tibiae with spines.
2 (3) Prolongations of connexivum blunt, rounded. Rostrum attaining hind coxae. ..... **laciniata (Vill.)** [7]
3 (2) Prolongations of connexivum pointed. Rostrum surpassing hind coxae. ..... **cf. algirica Guér.** [7]
4 (1) Antennal joint 2 and base of tibiae without spines. Each segment of the connexivum in the middle with a dark band. **cf. lacerata H.S.**

Phyllomorpha laciniata (Vill.) ?

This is an insect of sand dunes, being always found at the base of *Gramineae*, especially *Panicum turgidum* (VI-II). From Salloum to the Mariout and in Sinai. In the Delta at the borders of the desert, south to Helouan. Varying in colour from straw-yellow to dark brown, usually yellow with brown pattern.

Subfam. Pseudophloeinae Stal

Pseudophloeus Burm.

1 (6) Antennal joint 3 very slender and wholly yellowish, not thickened at apex. Scutellum all along with median carina.
2 (3) Posterior angles of prothorax simply rounded, not auriculate. Antennals 2, 3 and 4 stouter. Tubercles at the sides of the median line

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(7) The Egyptian specimens of *Phyllomorpha*, all we have seen belonging to one species, were identified by W.E. China as *laciniata* (Vill.), by K. Schmidt as *algirica* Guér.; we could not distinguish our species from European specimens of *laciniata*, but we have to note that the length of the rostrum of one specimen would agree with *algerica*, and that the prolongations of the connexivum are of the same shape in all specimens, i.e. *pointed*, in the European (from Albania) and Egyptian specimens alike.

of the pronotum separated from one another (Giarabub). ..... cf. gestroi Bergev.

3 (2) Margins of pronotum auriculate, posteriorly. Antennals 2, 3 and 4 more slender. Tubercles at sides of median line of pronotum very closely approximated, not distinctly separated.

4 (5) Body colour darker, brown. Form broader, head broad. Antennal 1 smaller, length about one-third of joint 3. ..... cf. falleni (Schill.)

5 (4) Body paler, testaceous, or pale with brown markings. Form more slender. Antennal 3 at most 2.5 times as long as 1, less slender. ... . angustus Reut.

6 (1) Antennal joint 3 incrassate and blackish at apex. Scutellum carinate at apex only. ..... cf. waltli (H.S.)

Pseudophloeus angustus Reut.

All over the Delta, the Mediterranean belt, southermost record : Beni Suef; Sinai (I-V, IX-XII). On the ground on uncultivated land, in the desert under scrub. — Specimens identified by Bergevin as *falleni* Schill. are *angustus* Reut.

Bathysolen nubilus (Fall.).

Oshanin records it from Egypt. It is not represented in any one of the Egyptian collections.

Ceraleptus obtusus (Brullé).

On waste land, in orchards, locally sometimes numerous. Only occasionally in the desert. All the year, widely distributed.

Loxocnemis dentator (F.).

Rare. Marg (V), coll. Alfieri (det. Horváth).

Coriomeris affinis (H.S.) ssp. aegyptiacus K. Schm.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 351).

Common on uncultivated land, in dry orchards, on and under halfa grass. Coastal area, Delta, and desert near cultivations. Practically all the year; rare at the light trap. Colour from testaceous to dark brown.

Subfam. Alydinae Stal

Stenocephalus Latr.

1 (2) Slender species of 2.2-2.4 mm. width. Colour testaceous to brown. Antennae pale, joint 3 darkened except at extreme base. ..... pallidus Sign.

2 (1) Broader forms. Body dark. Antennae darker and less slender.

3 (4) Antennae dark, joint 2 with two yellow rings, 3 and 4 yellow at

base. Femora yellow at base only. Bases and apices of tibiae narrowly black. Setae on antennae dark. ..... **setulosus Ferr.**

4 (3) Not agreeing with the characters indicated.

5 (6) Legs pale. Antennae very slender, particularly joint 1, provided with scattered raised hairs. Length of *pallidus*. ..... **spec. 3**

6 (5) Large, dark species. Corium mottled with black ; apical third of hind femora abruptly dark. ..... **spec. 4**

Stenocephalus setulosus Ferr.

Sinai (Rafah), coll. Alfieri, det. E. de Bergevin.

Stenocephalus pallidus Sign.

The only species of Egypt, proper, occurring particularly in the south (Upper Egypt), but not being common ; more numerous on the coastal plain of the Red Sea south of Kosseir, at Mersa Halaib and Gebel Elba ; Sinai (I-IV). Mostly taken at the lamp.

Stenocephalus spec. 3.

Gebel Elba (II-IV), under stones, on scrub, at the lamp.

Stenocephalus spec. 4.

Gebel Elba (Wadi Aideb), I-II, at the light. W.E. China considers this species new to science.

(Eremoplanus mucronatus Reut.).

Described from Arabia. A specimen (coll. Alfieri), identified by Bergevin, is identical with *Nariscus cinctiventris* Germ. The species is mentioned by Gulde (1920) from Sinai (III).

Sjoestedtina robusta Dist.

Wadi Umm-Assaad near Meadi, under *Retama raetam*, with larvae, 14.X.1934 (H. Priesner); Rabinovitch found this insect at km. 40 of the Suez Road (VI). Det. Izzard

Tenosius spec.

An as yet unidentified species occuring at Gebel Elba (I, II), collected by Priesner and seen by R.J. Izzard.

Camptopus lateralis (Germ.).

With var. *brevipes* H.S. (antennal joints 2 and 3 only distally dark, fore and middle femora with red) common all over the Canal Zone and the Delta. We have no records, as yet, from south of Giza Province. In the cultivated parts this species occurs in orchards and fields and borders of cultivations, gardens, etc. (II-X) ; it is rare in the desert.

Riptortus aegyptiacus Lindbg.

(*Bull. Soc. Fouad I d'Ent.*, XXII, 1938, p. 10, fig. 1).

With var. *vittatus* Lindb. (sides of body with elongate yellow spots) always found in the cultivated part of the country, but uncommon, on crops (cucurbits, cotton), *Gramineae;* south to Fayoum, east to Abu Sueir (III-IX).

Nemausus simplex Horv.

(cf. K. Schmidt, *Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 369).

In the Delta, Giza Province and Fayoum, confined to localities where *Acacia* grows (*A. farnesiana, nilotica*). Likes resting on the soil and taking hurridly to flight when disturbed, as the following species does. (V-II). Larvae in winter in old dry pods of *Acacia farnesiana.*

Nariscus cinctiventris (Germ.).

(cf. Lindberg, *Bull. Soc. Fouad I d'Ent.*, XXII, 1938, p. 12).

Much varying in size and colour. Like the former near *Acacias*, locally in numbers on shady places on the ground, flying for short distances like locusts. In the Delta (from Alexandria to Cairo), the oases Kharga and Dakhla, at Bir Abrag and Gebel Elba in the eastern desert. All the year.

Subfam. Corizinae Stal

Therapha hyosciami (L.).

(*Corizus hyosciami*).

Uncommon in Egypt. Gemmeiza, Tanta, Meadi, Fayed (V-VIII).

Liorhyssus Stal

1 (2) Body crimson, corium nearly opaque. .... **natalensis (Stal) v. corallinus Horv.**

2 (1) Yellow or brownish, much varying in coloration; if crimson, only the veins so, the rest of the corium transparent, pale. ... **hyalinus (F.)**

Liorhyssus hyalinus (F.).

All over Egypt (Marmarica, Mariout, all the Nile valley, Wadi Halfa, Gebel Elba, Sinai), the most common species of the family, the whole year, also in the deserts. At Fayed, this insect developed (all stages were seen) on *Sonchus oleraceus*, but it no doubt lives also on other plants, as larvae may be seen on *Helianthus* and *Zea.*

Extreme colour variations are the following : f. *nigrina* Reut., having head, antennae, dorsum of abdomen and femora blackish; f. *sanguinea* Costa, pale, with veins and margins crimson.

Liorhyssus natalensis (Stal) var. corallinus Horv.

Rare, in the north only : Mex (IV), coll. Alfieri.

Rhopalus subrufus (Gmel.).

Mentioned from Cairo (*Ann. Soc. Ent. France*, 1914, p. 133), though

most likely wrong identification, probably a dark variety of *Liorhyssus hyalinus* (F.).

Stictopleurus spec.

A unique specimen from Meadi (VI), coll. Alfieri.

Maccevethus persicus Jak.

From Wadi Gederât in Sinai (V).

Agraphopus Stal

1 (4) Hind femora not incrassate.

2 (3) Hind femora with very small tubercles, bearing small setae. Ultimate antennal joint dark. Body colour yellowish to greenish, costal margin of corium and median line of abdomen sometimes dark, or some veins orange. Membrane shorter than in *pallens*. ..... **lethierryi Stal**

3 (2) Hind femora and tibiae without tubercles. Antennae wholly pale, terminal joint at most *slightly* shaded. Body pale stramineous, much more slender. Pronotum, scutellum and membrane longer. Hind femora more slender. ..... **pallens K. Schmidt**

4 (1) Hind femora incrassate, nearly attaining apex of abdomen, with a row of spines or teeth at lower margin. Tips of hind tibiae and of hind tarsi often blackish.

5 (6) Head and pronotum strongly convex, the latter much narrowed anteriorly. Antennal joint 4 shorter than 3, in both sexes. Membrane reaching apex of abdomen. Dorsum of abdomen pale. .... **femoralis Horv.**

6 (5) Head and pronotum less convex, less narrowed towards apex, the latter shorter than the head, in the female. Antennal joint 4 of male as long as 3. Membrane shorter, not fully covering last abdominal segment. Dorsum of abdomen with dark median line. .... **cf. viridis (Jak.)**

Agraphopus lethierryi Stal.

All over the cultivated Egypt, on grasses and shrubs, also at the light traps, fairly common. The whole year.

Note : Specimens identified *viridis* (Jak.) by Bergevin are identical with *lethierryi* Stal.

Agraphopus pallens K. Schmidt.

Uncommon, but at times appearing in numbers at the light. A desert species (III-V). Lower and Upper Egypt ; Sinai.

Agraphopus femoralis Horv.

Meadi (VIII), Wadi Rishrash (III), rare.

5. Family PYRRHOCORIDAE Fieb.

1 (2) Segments of rostrum of about equal length. Abdomen at least partly red beneath. ..... **Scantius Stal**

2 (1) Segments of rostrum of unequal lengths. Abdomen black. .... **Pyrrhocoris Fall.**

Pyrrhocoris Fall.

Members of this genus were not observed hitherto in Egypt, but may occur in the coastal parts of the country, perhaps in Sinai, too. Storey's *Pyrrhocoris apterus* (L.) is, however, *Scantius forsteri* (F.).

Scantius Stal.

1 (2) Corium red with black spot in the middle. Scutellum black. .... **aegyptius (L.)**

2 (1) Corium black or dull red, with red lateral margins. Scutellum black, with red apex. ..... **forsteri (F.)**

Scantius aegyptius (L.).

A Mediterranean insect, occurring only in the coastal regions, from Salloum to Port-Said, south along the Suez Canal and on the coasts of Sinai. Southermost record : Fayed. The whole year on the ground and under stones, sometimes in clusters. When found in the Delta it was obviously carried by the wind.

Scantius forsteri (F.).

Forma brachyptera and macroptera. Like the foregoing species, but, as it seems, more local; on the sand, near shrubs and grass, under stones. Also in the oasis Siwa, where several other Mediterranean insects occur. Sinai.

6. Family MYODOCHIDAE Kirk. (Lygaeidae Schill.)

Key to subfamilies

1 (2) Eyes very large, strongly protruding, nearly as large as one-half of head. Body short and stout. ..... **Geocorinae Stal**

2 (1) Eyes smaller.

3 (4) Eyes pedicellate. Body more elongate. ..... **Henestarinae Stal**

4 (3) Eyes not pedicellate.

5(18) Submarginal line of sternite III of abdomen extending to lateral margin of abdomen.

6 (7) Cheeks nearly as long as clypeus. Small forms. **Artheneinae Stal**

7 (6) Cheeks distinctly shorter than clypeus, the latter protruding.

8(11) Hemielytra of macropterous form not attaining apex of abdomen, at least one tergite remaining uncovered. Usually slender, elongate forms. Pronotum without transverse impressed line, anteriorly.

9(10) Cavities of fore coxae situated on disc of prosternum. Antennae rather long, slender. Body strongly flattened dorsoventrally, *or* set with raised hairs. ..... **Blissinae Stal**

10 (9) Coxal cavities of prosternum situated at hind margin of it. Antennae shorter than one-half of body. Stramineous in colour. Fore femora much larger than middle and hind femora, furnished with spines. ... . **Pachygronthinae Stal**

11 (8) Elytra of macropterous form usually attaining apex of abdomen or surpassing it. Brachypterous form having transversal furrow of pronotum, and being of stouter build.

12(15) Corium not or indistinctly punctured.

13(14) Pronotum with transverse, sinuated, impressed line, in anterior portion. ..... **Lygaeinae Stal (Astacopinae Kirk.)**

14(13) Pronotum without transverse impressed line, anteriorly. .... **Oxycareninae Stal**

15(12) Corium with distinct punctuation.

16(17) Punctuation of corium colourless or pale. Costal margin of corium dilated, corium broader than abdomen. Smaller forms. .... **Cyminae Stal; cf. Pachygronthinae St.**

17(16) Punctuation of corium darker, always in longitudinal rows. Sides of abdomen surpassing margin of corium, connexivum thus well visible. ..... **Heterogastrinae Stal**

18 (5) Submarginal line of abdominal sternite III not attaining lateral margin but directed forward and hook-like bent backward, at the sides. ..... **Aphaninae L.S.**

1. Subfamily Lygaeinae Stal

Key to genera

1(18) Hemielytra fully developed.

2(13) Suture between corium and membrane straight or nearly so.

3(10) Red and black coloured forms, often with white dots. Surface not clothed with raised hairs.

4 (5) Red longitudinal keel of pronotum attaining fore margin. Head black, with small red dot on vertex. Lateral margin of pronotum ciliate. ... . **Tropidothorax Bergr. (Lygaeus F.)**

5 (4) Red longitudinal carina of pronotum not reaching fore margin.

6 (9) Head red and black.

7 (8) Membrane with white spots. ..... **Spilostethus Stal**
8 (7) Membrane dark, only with whitish margin, without spots. ..... **Graptostethus Stal**
9 (6) Head black. Smaller species. ..... **Melanocoryphus Stal**
10 (3) Brown and black, sometimes with white spots. Raised hairs on dorsal surface. Comparatively small forms.
11(12) Larger, 5.5-6 mm., body with long, raised hairs. Brownish red and black. ..... **Melanotelus Reut.**
12(11) Smaller, 2.7-3.6 mm. Hairs shorter. Testaceous and black. ..... **Lygaeosoma Reut.**
13 (2) Suture between corium and membrane undulated. Yellow, testaceous to brownish forms.
14(15) Rostrum shorter, attaining about middle coxae. ... **Paranysius Horv.**
15(14) Rostrum long, attaining or surpassing hind coxae.
16(17) Apex of scutellum straight. Legs and antennae normal, the latter of equal shape in both sexes. ..... **Nysius Dall.**
17(16) Apex of scutellum distinctly reflexed. Legs and antennae longer and more slender, the latter usually dimorphous. Head narrower, eyes less prominent. ..... **Nysiodes Dist.**
18 (1) Hemielytra reduced to small pads. Body elongate, depressed. ..... **Apterola M.R.**

Tropidothorax leucopterus (Goeze).

Rare. We only know a few specimens (coll. Alfieri) from Suez (V), and (coll. Soc. Fouad I Entom.) from Nawa (III).

Spilostethus Stal

1 (2) All legs and most of antennae fulvous, the former seldom somewhat shaded with brown. Corium with a small black dot in the middle. ... **fulvipes (Dall.)**
2 (1) Legs and antennae dark.
3 (6) Sternum black or partly dull reddish. Femora of male without spines.
4 (5) Pronotum with two broad black longitudinal spots. Body very slender. **longulus (Dall.)**
5 (4) Pronotum black only at fore and hind margin. Less slender. ..... **equestris (L.)**
6 (3) Sternum black, with three red spots. Femora of male with spines.
7 (8) Exterior margin of corium red. Membrane varying in colour. Length 12-14 mm. ..... **pandurus (Scop.)**
8 (7) Exterior margin of corium black. Membrane whitish. Length 10-11 mm. ..... **saxatilis (Scop.) var. lusitanicus (H.S.)**

Spilostethus (Cosmopleurus Stal) fulvipes (Dall.).

A no doubt southern species. Common in the oases (Kharga, Dakhla), in Upper Egypt south to Wadi Halfa (III, IV, IX, XII). Single specimens were taken further north (Fayed, Maksama, Wadi Rashid), but these might have been carried there by the wind. The insect lives on the ground, near small canals of wells and springs (oases), under low plants and bushes.

Spilostethus longulus (Dall.).

In the desert valleys, borders of desert, on the ground, at the base of plants (I-III, VII-X). Widely distributed : Coastal areas, Delta and Upper Egypt ; Sinai ; Gebel Elba.

Spilostethus equestris (L.).

Bodenheimer lists this species from Sinai. I suspect the identification to be incorrect, as this species is very similar to *longulus* (Dall.).

Spilostethus pandurus (Scop.).

Common everywhere in Egypt, from the coast to Asswan and in Sinai. All the year round. Larvae in clusters on the ground by trees and bushes. Forma *militaris* F. (membrane whitish) less numerous.

Spilostethus saxatilis (Scop.) var. lusitanicus (H.S.).

A unique specimen was taken by C. Koch (III) at Salloum.

Melanocoryphus Stal

1 (4) Corium with discal black spot not reaching costal margin. Clavus black. Membrane without white apical spot.

2 (3) Abdomen vermilion, with black marginal spots at base and apex. ..... **cf. albomaculatus (Goeze)**

3 (2) Abdomen black, or only apically so, but lateral margin always vermilion. ..... **tristrami (Dgl. Sc.)**

4 (1) Corium with black spot attaining lateral margin. Clavus almost wholly red. Membrane with white apical spot.

5 (6) Sternum, except anterior lobe of prosternum, black, posterior margin of metasternum sometimes pale. Spot on membrane somewhat elongate. Length 5-6 mm. ..... **syriacus (Reut.)**

6 (5) All posterior margins of sternal plates pale or red. Hind margin of prosternum with black spot. White spot on membrane circular or united with pale margin. Length 4-5 mm.

7 (8) Clavus with black pre-apical stria. Spot on membrane free. ..... **sanctus Horv.**

8 (7) Clavus red. White spot of membrane united with margin by a white transverse band. ..... **sanctus Horv. f. insons Horv.**

Melanocoryphus syriacus (Reut.).

Rare, in the Marmarica; det. K. Schmidt.

Melanocoryphus sanctus Horv. and f. insons Horv.

Widely distributed, but uncommon; e.g. on *Citrullus colocynthis* in the desert valleys or in the northern steppe. Mariout, Alexandria, Wadi Gerawi, Wadi Hof (III-VI, X-XI).

Melanocoryphus tristrami (Dgl. Sc.).

Recorded from Sinai (Wadi Gergir), by Bodenheimer.

Graptostethus servus (F.).

Fairly common in the cultivated parts, under bark of trees (*Acacia*), in cotton fields, orchards, etc., sometimes in associations.

Delta, Canal Zone, Giza Province. All the year.

Melanotelus villosulus (Stal).

Rare (X-I), under *Tamarix*, *Zygophyllum*, certainly widely distributed.

Records : Cairo region, Arabian desert; Gebel Elba.

Apterola angusticollis Lindbg.

Rare. Helwan (VIII) and Mersa Halaib (I) (cf. *Bull. Soc. Fouad I Ent.*, XXII, 1938, p. 13, fig. 2).

Lygaeosoma reticulatum (H.S.) var. numidicum Put.

In the northern steppe under stones (IV, VIII), scarce.

Other records : Alexandria, Cairo, Pyramids of Giza, Wadi Gerawi, Wadi Ibtadi (I-VIII).

Bergevin's *angulare* Reut. refers to this species.

Paranysius fallaciosus (Put.) subsp. priesneri China.

(*Ann. Mag. Nat. Hist.* (10), XVI, 1935, p. 467).

Kom Ombo, in orchards under stones and clods of soil (III, XI).

Nysius Dall.

1 (2) Genal plates surpassing base of head, forming a small, free lobe. ... . **cf. immunis Walk.**

2 (1) Genal plates attaining base of head, or being even shorter.

3 (8) Exterior margin of corium at base with short and fine, somewhat raised hairs.

4 (7) At least exterior vein of corium spotted with brown. Rostrum blackish.

5 (6) Pronotum broader. Head, pronotum and scutellum without distinct ground-pubescence. Punctuation of prothorax coarser. .... **(cf. ericae (Schill.))**

6 (5) Punctuation of prothorax finer and denser. Colour much paler. Head, pronotum and scutellum with very fine, golden ground-pubescence. ..... **cymoides (Spin.)**

7 (4) Veins of corium pale. Pronotum longer than one-half of its basal width. Antennal joints 2 and 3 usually brownish at extreme base. ... . **graminicola (Klti.)**

8 (3) Exterior margin of corium without a trace of pubescence, smooth. Anterior transverse furrows of pronotum *pale*. Body wholly pale brownish yellow. ..... **senecionis (Schill.) ssp. aegyptiaca nov.**

(Nysius ericae (Schill.)).

Some specimens of the collection of the Ministry of Agriculture were referred to this species, but we consider them belonging to *cymoides*, a very variable species. Specimens under the above name from Europe (ex coll. Singer) belong to *thymi* Wlff.

Nysius cymoides (Spin.).

Common all the year all over the country, and Sinai. Occasionally this species may be observed swarming in great numbers. It is often taken at the light. Usually it is found on the ground, on low plants, under detritus, but also on shrubs and trees, soiling the leaves with its excrements.

Nysius graminicola (Klti.).

Widely distributed and common like the foregoing species, on all kinds of plants, particularly in orchards, on field borders, canal banks and waste land. It also appears in great numbers when drought sets in, and the insects are forced to leave the dry plants in search for other places where they can live. Found all the year, all over Egypt.

Nysius senecionis (Schill.) ssp. aegyptiacus nov.

This form is distinguished from the typical *senecionis*, a species common in Europe, by its entirely pale ochrous colour, whereby even the transverse, impressed striae of the pronotum remain pale. W.E. China considers this form a variety of *senecionis* rather than a new species. It is not so common as the somewhat similar *graminicola* but is widely distributed, taken from Alexandria over the Delta to Upper Egypt (Shekh Fadl, Asswan), practically all the year round. It lives on weeds, e.g. *Erigeron crispus*.

Nysiodes longicornis (Put.).

Uncommon, near cultivations and in the desert valleys near Cairo (III-X), usually caught at the lamp; Sinai (Wadi Feirân).

2. Subfamily Cyminae Stal

Key to genera

1 (2) Antennal joints 2 and 3 little differing in length. Fore angles of

pronotum blunt. Antennal 1 not or scarcely reaching apex of head. ..... **Cymus Hahn**

2 (1) Antennal 3 twice as long as 2. Fore angles of pronotum pointed. Antennal 1 somewhat surpassing apex of head. ..... **Cymodema Spin.**

Cymus minutus Lindbg.

(*Bull. Soc. R. Ent. d'Egypte*, XXII, 1938, p. 14).

In the cultivated parts of the country this species may be locally numerous on damp places on *Phragmites* and other *Gramineae* or on *Cyperaceae* (II-IX). Delta, Canal Zone, Fayoum. Sinai.

Cymodema tabidum Spin.

This species, too, seems to be confined to moist localities; it is found on lawns and canal banks where *Scirpus* grows. We know it from Meadi (XI) and Wasta (III), in greater numbers it was collected by Priesner under fallen leaves of a hedge of *Schinus terebinthifolius* (X) at Serw (lake Menzala).

3. Subfam. Blissinae Stal

Key to genera

1 (2) Antennae longer than head and pronotum combined. Fore coxae closed in front. Macropterous and brachypterous. . **Ischnodemus Fieb.**

2 (1) Antennae shorter. Fore coxae open in front. Macropterous. Less elongate and less depressed. Pilose. ..... **Blissus Burm.**

Ischnodemus caspius Jak.

Common with larvae under the leaf sheaths of *Typha angustata*, all over the country, the whole year. The macropterous form, however, is rather rare, we only got it from the lamps (Cairo, Meadi).

Blissus hirtulus Burm.

Uncommon, at the base of grasses, in detritus, in the Delta and nearby deserts, from Dekheila (Mariout) to Wasta (Upper Egypt) and in the oasis Dakhla (V-I).

4. Subfam. Henestarinae Stal

Key to genera

1 (2) Pronotum distinctly narrowed towards apex, much less than twice as broad as long. Eyes pedicellate. ..... **Henestaris Spin.**

2 (1) Pronotum nearly twice as broad as long. Eyes much less strongly protruding. ..... **Engistus Fieb.**

Henestaris Spin.

1 (2) Pedicels of eyes directed backward. Prolongation of lateral margin

of pronotum passing through eye. Frons nearly vertical. Antennal joints 2 and 3 pale, with dark ring at base and apex. .... **thoracicus K. Schmidt**

2 (1) Pedicels of eyes long, horizontal or directed somewhat forward; eyes much distant from fore angles of pronotum. Imaginary prolongation line of pronotal margin directed towards interior margin of eye or even further inward.

3 (4) Smaller, length 4-4.65 mm. Antennal 2 and usually also 3 black at apex. Apices of tibiae mostly pale. ..... **curtulus Horv.**

4 (3) Larger, length 5-6 mm. Antennal joint 3 mostly wholly pale. Tips of tibiae very often dark. Pronotum somewhat longer. .... **laticeps (Curt.)**

Henestaris curtulus Horv.

El-Rico (X) (type in coll. Alfieri).

Henestaris laticeps (Curt.).

Much varying in colour and size, and perhaps not specially different from *curtulus*. In the northern steppe only, e.g. Dekheila (Mariout), fairly common; Damiette (VII-X).

Henestaris thoracicus K. Schmidt.

(*Bull. Soc. Fouad I d'Entom.*, XXIII, 1939, p. 369, figs. 5-8).

Borg-el-Arab, Matrouh (VII, VIII). On the ground on damp localities of the coastal planes.

Engistus Fieb.

1 (2) Head, inclusive of eyes, broader than hind margin of pronotum. Antennal joint 1 more strongly incrassate. ..... **boops (Duf.)**

2 (1) Head not broader than hind margin of pronotum. Much varying in colour. ..... **exsanguis Stal**

Engistus boops (Duf.).

This species was found only in the north (Dekheila, Mex, Damiette, Abukir), and in the oases Siwa and Dakhla (III, IV, VIII, XI). It seems to be confined to salt marshes.

Engistus exsanguis Stal.

A very common species of the desert valleys, from the northern coast all over the country, south to Mersa Halaib. Always under *Zygophyllum*, *Haloxylon* and other shrubs, all the year. The normal form is yellow to testaceous or light brown; f. *fasciata* Horv. is based on specimens that are spotted with brown and show a dark cross-band on the corium; f. *conspurcata* Horv. is more or less mottled with dark brown, or uniformly brown;

there are wholly orange coloured specimens (f. *crocea* nov.) and greenish yellow or green ones (f. *viridis* nov.).

5. Subfamily Geocorinae Stal

Key to genera

1 (6) Body without raised hairs on the dorsum, but often with fine pubescence.
2 (3) Body much elongate, slender, depressed. .....**Stenophthalmicus Costa**
3 (2) Body short and stout.
4 (5) Body very short and strongly convex. Head strongly transverse. Joint 2 of rostrum longer than 3. Scutellum short, somewhat rounded at apex, and usually with smooth calli at fore angles. .....**Piocoris Stal**
5 (4) Body less stout and convex. Joint 2 of rostrum shorter than 3. Scutellum without calli at base, sharply pointed at apex. **Geocoris Fall.**
6 (1) Body with conspicuous raised hairs on dorsum, on legs and antennae. .....**Mallocoris Stal**

Piocoris Stal

1 (4) Shortly built species, ochrous, yellowish or brownish in colour.
2 (3) Lateral scutellar calli smooth, conspicuous. Colour paler. The smooth longitudinal line of the scutellum rather broad and well visible, base of scutellum with some dark punctures. At least antennal joint 1 darkened. .....**luridus (Fieb.)**
3 (2) Scutellar calli wanting or scarcely discernible, punctures at base not dark. Colour somewhat darker, brownish to ferrugineous. Antennae little darkened. ..... **nebulosus Mont.**
4 (1) Elongate, similar in shape to most *Geocoris* spp. Body with crimson markings. ..... **confalonierii Bergev.**

Piocoris luridus (Fieb.).

Widely distributed, usually found (with larvae) on *Tamarix* or *Acacias* or their detritus (II, IX, X). Delta and Upper Egypt; Sinai.

Piocoris nebulosus Mont.

At the base of *Gramineae*, on trees (*Acacia*), at the border of the desert, not common, only locally more numerous. Delta and Upper Egypt; Sinai. Presumably all the year.

Piocoris confalonierii Bergevin.

A Mediterranean element. Romani (Sinai), in V, VIII, collected by A.W. Boyd; det E. Wagner.

Geocoris Fall.

1(18) Pronotum densely or sparingly, but rather *coarsely*, punctured.

2(15) Antennae with adpressed or only slightly raised, soft hairs.

3 (4) Slender species, head and prothorax metallic black, shining, the latter medianly at fore margin and at least at posterior angles whitish yellow. Corium yellow, interior angle blackened (more extensively so in f. *falsata* Mont.). ..... **acuticeps Sign.**

4 (3) Not the above characters combined.

5 (8) Smaller, more slender species. Head very finely rugose, or shining only at posterior margin of vertex.

6 (7) Pronotal calli flattened, dull, not or scarcely shining, very finely rugose. General colour brownish yellow, but darkened here and there, particularly on vertex and middle of pronotum. Antennal 2 not abruptly white apically. Head about as broad as pronotum at posterior margin. ..... **scutellaris Put.**

7 (6) Pronotal calli shining, black. Antennals 1 and 2 black, abruptly whitish at apex. Head somewhat broader than pronotum at posterior margin. Pronotum for the greater part black. ... **pallidipennis (Costa)**

8 (5) Somewhat larger, shortly and broadly built species, with dorsal surface of head, at least medianly, shining, smooth. Corium and scutellum with conspicuous pilosity (if not rubbed).

9(10) Head with large, median, black spot. Pronotum anteriorly with two large black spots, rarely nearly wholly dark, and in this case also head dark with pale median line (f. *dolosa* Mont.). Scutellum black at base. Fore margin of pronotum very sparingly punctured. .... **collaris Put.**

10 (9) Pronotum either more densely punctured in front of calli, or, if sparingly so, pronotum not with two black spots. Head never entirely black, usually for the greater part or wholly pale, yellow or orange.

11(12) Punctuation of pronotum in front of calli scarce and irregular. Either wholly pale stramineous or vertex posteriorly and scutellum basally dark. ..... **arenarius (Jak.)**

12(11) Punctuation of pronotum, in front of calli and posteriorly, more regular and much denser.

13(14) Corium entirely pale. Otherwise much varying in colour. .... **megacephalus (Rossi)**

14(13) Corium with a large, roundish, dark spot at interior angle, or black, with yellowish margins and base. Head fulvous or darkened posteriorly, punctuation of pronotum dense and coarse, as in *megacephalus*. Scutellum short. ..... **timidus (Put.), Mont.**

15 (2) Antennae, at least joint 2, with finer or stouter raised bristles.

16(17) Large species, 4 mm. long and more. Head very large, usually black, as the pronotum. Dorsum of body (inclusive of head) with dense pilosity. ..... **hispidulus Put.**

17(16) Smaller. Yellow, head, pronotal calli, base of scutellum, apical spot of corium and nearly the whole femora crimson or ferrugineous. ... . **cf. Piocoris confalonierii Bergevin**

18 (1) Pronotum very finely and densely punctured, dull. Pale yellow (f. *henoni* Put.) or head and anterior margin of pronotum more or less darkened. Second antennal joint with bristles. ..... **nigriceps Reut.**

Geocoris scutellaris Put.

Not rare, in the Delta, the northern coast and Canal Zone. On the ground, under shrubs and grasses (*Panicum*), or at the lamp. All the year. One specimen from Gebel Elba; Sinai.

Geocoris acuticeps Sign.

On the ground, under *Tamarix*, on waste land under *Panicum turgidum* and halfa grass, fairly common; f. *falsata* Mont. rare. All over the country and all the year round.

Geocoris pallidipennis (Costa).

Not common. Meadi, Gebel Asfar, Fayoum (III-VI).

Geocoris timidus Put.

Type from Eioun Musa (Sinai). A specimen from Helouan (in coll. Alfieri, det. Montandon) does not well agree with the description of the type, by Puton. The type specimen is black with head reddish, vertex darkened, corium with narrow reddish margins. Antennae black, ultimate joint red.

Geocoris megacephalus (Rossi).

The most common species of the genus. Under grasses, herbs, also in the desert. All over the Delta, including the Mediterranean Zone and the Canal region (VI-XII).

The species varies greatly in colour, the varieties are, however, not sharply defined and transitions are common. In f. *deserta* Mont., the pronotum is darkened anteriorly, the dark part about triangular, not straight, posteriorly. In f. *anemiata* Mont. the major portion of the pronotum is dark, margins pale, the dark part not triangular but straight at posterior margin. In f. *occipitalis* Duf., the hind margin of the vertex is blackish, too; f. *villosula* Mont. is obviously based on non-rubbed specimens.

Geocoris arenarius (Jak.).

Delta and Giza Province; Sinai. Uncommon, (VI-XII); f. *lauta* Mont.

has pronotum anteriorly and scutellum basally somewhat darkened; f. *albida* Jak. (*fedtschenkoi* Reut.) is wholly stramineous or eburneous, sometimes with base of scutellum slightly darkened.

Geocoris collaris Put.

Widely distributed, from Matrouh to Sinai in the north, and in the Nile valley south to Fayoum. Much less numerous than *megacephalus* or *nigriceps henoni*. All the year. Of varieties, f. *confluens* (with the two dark pronotal spots fused to one) and f. *dolosa* (head dark) were found in this country, the latter being rare (Sakkara, XII).

Geocoris hispidulus Put.

A rare species, recorded from Cairo, Meadi and Helwan (V-VIII, XII).

Geocoris nigriceps Reut.

The typical form (head and fore margin of pronotum darkened) is uncommon, but f. *henoni* Put. may be encountered all over the country on sandy places, especially in the desert valleys under *Zygophyllum*, *Tamarix* and other shrubs, on and under grasses, in detritus, etc. All the year, locally often numerous. Sinai. Southermost record : Wadi Abrag.

Mallocoris discifer Stal.

Cairo, Pyramids of Giza, Kerdaza, rather rare, under Halfa grass, *Panicum*, etc. (II, IX), collected by Montandon and Ferrante.

Stenophthalmicus Costa

1 (2) Dark brown to blackish, at least head and pronotum so. .... **fayoumensis Costa**

2 (1) Pale yellow or brownish yellow species.

3 (4) Antennae stout, irregularly clothed with numerous dark bristles. Usually brownish yellow or orange in colour. ..... **hirticornis Lindbg.**

4 (3) Pale stramineous. Antennae appearing slender.

5 (6) Very slender, elongate species. Pronotum nearly square; punctuation near fore margin very scarce, interrupted in the middle; punctuation in posterior part of pronotum very sparingly set, too. Membrane not reaching apex of abdomen. ..... **biskrensis Put.**

6 (5) Less slender. Punctuation of pronotum coarse, as in the former, but rather dense, at least in posterior portion. Scutellum less slender, transverse callus conspicuous, base of scutellum with some punctures. Membrane reaching apex of abdomen. ..... **panici Pries.**

Stenophthalmicus fayoumensis Costa.

Delta, Giza Province, Canal Zone, always in or near cultivations, e.g. canal banks, not in the desert. It is swept from grasses on moist places All the year.

Stenophthalmicus hirticornis Lindbg.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 16, fig. 3).

All the year, the most common species of this genus, on and under halfa grass and *Panicum turgidum* at the borders of the desert, in the provinces Menufia and Giza.

Stenophthalmicus biskrensis Put.

Gebel Asfar sand dunes, 11.IV.1933, on a *Gramineae* species (leg. H. Priesner).

Stenophthalmicus panici Pries.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, pp. 137-138).

Pyramids of Giza; Mansuria, Suez Road (XI-III), always on the desert grass *Panicum turgidum*, or on the ground near it.

6. Subfamily Artheneinae Stal

Key to genera

1 (2) Pronotum with longitudinal furrow. Eyes small. ..... **Artheneis Spin.**

2 (1) Pronotum without longitudinal furrow. Eyes large. Head with two complete longitudinal furrows. ..... **Holcocranum Fieb.**

Artheneis Spin.

1 (2) Antennal joint 2 very long, five times as long as joint 1, and twice as long as joint 3. Scutellum with V-shaped, elevated, white callus. Colour whitish yellow. Punctuation much finer than in the following forms, scarcely visible on the hemielytra. (Giarabub). ..... **cf. chlorotica Bergevin**

2 (1) Antennal joint 2, in comparison to joints 1 or 3, much shorter.

3 (6) Scutellum with V-shaped, pale callus, occupying most of its dorsum.

4 (5) General colour paler, antennal joints 1 to 3 always yellow. Scutellar carina broader, forming a blunt callus. Somewhat smaller species, length 2.6 mm. ..... **aegyptiaca Lindbg.**

5 (4) General colour darker, antennal 1 partly brown, joints 2 and 3 dark at base, 4 dark in apical half. (South Europe, Algeria, Turkey). ..... **cf. foveolata Spin.**

6 (3) Scutellum at basal angles with short callus, coarsely punctured. Antennae pale, joint 4 distally or also joint 1 dark. Legs pale. Corium distinctly darkened at apex. ..... **alutacea Fieb.**

Artheneis aegyptiaca Lindbg.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 15).

Very common, but previously confused with *foveolata* Spin. All over the Delta and Upper Egypt, the whole year on and under *Tamarix*.

Artheneis alutacea Fieb.

Seems to be confined to the northern parts of the country. We saw a few specimens from Montaza (VI) and from the Suez Road (III), on *Tamarix*.

Holcocranum eburneum Bergevin.

Uncommon but widely distributed (Mex, Tanta, Mengheb, Giza, Helwan, Fayed), IV, V, IX, in stems of *Phragmites*, *Typha* and on sugar cane; det. K. Schmidt.

7. Subfamily Heterogastrinae Stal

Only genus : *Heterogaster* Schill.

Heterogaster urticae (F.).

Not common. In orchards and gardens, on herbs and at the lamp. Borg-el-Arab, Alexandria, Gebel Asfar, Meadi, Fayed (I-VI, X-XI).

8. Subfamily Pachygronthinae Stal

Only genus : *Cymophyes* Fieb.

1 (2) Pronotum shorter. Membrane attaining apex of abdomen. .... **decolor Stal**

2 (1) Pronotum more elongate. Membrane not attaining apex of abdomen.... ..... **ochroleuca F.**

Cymophyes ochroleuca F.

Common on *Panicum turgidum* (IV-IX). Amriah, Gebel Asfar, Pyramids of Giza, Helwan, Fayoum.

Cymophyes decolor Stal.

Common all the year on *Panicum turgidum*, once on sugar cane. Most likely all over the Delta.

9. Subfamily Oxycareninae Stal

Key to genera

1 (2) Fore femora unarmed, only with some bristles. Head and prothorax blackish, bare. Hemielytra dark, marked with white. .... **Macropterna Fieb.**

2 (1) Fore femora with one or several teeth or spines.

3 (4) Genal plates long. Fore femora with two large and a few smaller teeth. ..... **Oxycarenus Fieb.**

4 (3) Genal plates smaller. Fore femora with only one conspicuous, and sometimes a very small tooth, in addition.

5 (8) Head large, convex, *constricted* at base. Corium short, membrane long.

3 (7) Body less slender. Pronotum slightly convex, not depressed posteriorly, trapezoid. Head not broader than pronotum at hind margin. ..... **Auchenodes Horv.**

7 (6) Body slender. Pronotum strongly convex, depressed posteriorly, constricted. Head (with eyes) broader than pronotum at hind margin. ... . **Bycanistellus Reut.**

8 (5) Head not constricted posteriorly. Corium and membrane normal.

9(10) Head and prononum distinctly pilose, blackish. ..... **Microplax Fieb.**

10 (9) Head and pronotum very slightly pilose. Yellowish brown species, having teeth of fore femora weak. ..... **Leptodemus Reut.**

Macropterna inermis Fieb.

Very common, everywhere, particularly in the desert, under shrubs, herbs and grasses. Sometimes very abundant and no doubt occasionally forming swarms. May become a nuisance through soiling stored grain in open stores. All the year. It attacks man, piercing the skin when thirsty.

Leptodemus Reut.

1 (2) Head (inclusive of eyes) longer than broad, as long as pronotum. Antennal joint 1 somewhat surpassing head. Femora pale. Abdomen with two (female) to four (male) ferrugineous longitudinal bands. ... . **bicolor Ldbg. var. ventralis K. Schmidt**

2 (1) Head somewhat broader than long. Antennal joint 1 attaining apex of head. Femora pale only at apex, at the most. ..... **minutus (Jak.)**

Leptodemus bicolor Lindbg. var. ventralis K. Schm.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 20, fig. 4).

Giza Pyramids, XI, under *Panicum turgidum* (leg. H. Priesner).

Leptodemus minutus (Jack.).

Common on the ground, particularly in the desert valleys, even by scarce vegetation, running in numbers and readily taking to flight. May be seen numerously in open grain stores.

Delta, Canal Zone, Giza Province, Oases (III, V-IX).

Much varying in colour : f. *albicans* Reut. has venter whitish or yellowish, banded with brown; in f. *pallidula* Reut. the venter is blackish brown, as in the typical form, but the corium is wholly pale, while it is brown at apex in the typical *minutus* (Jak.).

Microplax interrupta (Fieb.).

Fairly common all the year, under halfa grasses and *Panicum* Nile Delta, Cairo, Fayoum, Canal Zone. Also in the desert.

Bycanistellus naso Stal.

Rare. Hammam (Mariout) (V), one specimen in coll. Alfieri.

Oxycarenus Fieb.

1 (2) Pronotum wholly black. Larger species. ..... **hyalinipennis (Costa)**
2 (1) Pronotum yellowish, with broad transverse band in anterior half. Length 3-4 mm. ..... **pallens (H.S.) (collaris M.R.)**

Oxycarenus hyalinipennis (Costa).

A minor pest of cotton (cf. Kirkpatrick, 1923; Willcocks, 1937). All over Egypt and Sinai, especially on *Malvaceae*. Hibernating and aestivating in pods of various plants, in great numbers in those of *Althaea*, *Abutilon*, *Sterculia* and in cotton bolls, or under the bark of trees. Also in the desert, but chiefly carried there by the wind.

Oxycarenus pallens (H.S.) (collaris (M.R.).

Not common. Delta, Giza, Fayoum and desert (III, V-VIII). May be caught at the lamp, like the former.

Auchenodes peyerimhoffi Royer.

Mt. Sinai (Bodenheimer's list).

10. Subfamily Aphaninae L.S.

Key to genera

1(10) Pronotum strongly constricted behind middle.
2 (3) Pronotum long, anterior portion (in front of constriction) longer than width of pronotum at anterior margin. Incrassate part of anterior margin broad. Much elongate forms. ..... **Paromius Fieb.**
3 (2) Pronotum shorter, anterior part not longer than broad.
4 (5) Ant-like form. Head pedicellate. Hemielytra dark brownish, marked with yellow and white. ..... **Aegyptocoris China**
5 (4) Not formicoid.
6 (9) Fore femora distinctly enlarged. Surface, at least of hemielytra, dull. Strongly sclerotized, dark forms.
7 (8) Surface dull, head and pronotum with silky ground-pubescence. ..... **Pachybrachius Hhn. (Pamera auct., Orthaea Dall.)**
8 (7) Surface of head and pronotum shining, with coarse punctuation. Corium with black posterior cross-band and pale subapical spot Membrane with pale apical spot. ..... **Polycrates Stal**
9 (6) Fore femora scarcely enlarged. Body yellow and fulvous, shining. Mirid-like form, having legs and antennae very slender and body weakly sclerotized. ..... **Marmottania Put.**
10 (1) Pronotum without conspicuous constriction, fore margin not separated neck-like.

11(28) Margin of pronotum somewhat flattened, sharp.

12(21) Antennae set with short or inconspicuous setae, or finely pubescent. The flattened lateral margins of the pronotum scarcely punctured.

13(20) Head not broader than fore margin of pronotum.

14(15) Body comparatively broad, black. Segments 2 and 3 of rostrum of about equal length. ..... **Aëllopus Wlff. (Microtoma Lap.)**

15(14) Body narrower, seldom black. Segment 2 of rostrum longer than 3.

16(19) Lateral margin of pronotum broad. Black *and* yellowish brown to reddish brown forms.

17(18) Surface without conspicuous pilosity. Fore femora with small teeth. ..... **Aphanus Lap.**

18(17) Surface densely pilose. Fore femora with three large teeth. .... **Lachnophorus Reut.**

19(16) Lateral margin of pronotum narrow. Wholly black species (if ferrugineous or brown, cf. *Lethaeus*). ..... **Raglius Stal**

20(13) Head broader than fore margin of pronotum, eyes distant from the latter. More vividly coloured, large, slender forms. Sides of pronotum fairly straight. ..... **Dieuches Dhrn.**

21(12) Antennae with stout bristles. The flattened margins of the pronotum with conspicuous punctuation.

22(25) Pronotum broader than long. Scutellum about as long as pronotum. Head broader than long.

23(24) Fore margin of pronotum straight. Antennal hump curved anteriorly. Rostrum attaining middle of *mesosternum*. ..... **Gonianotus Fieb.**

24(23) Fore margin of pronotum concave. Antennal tubercle blunt. Rostrum attaining middle of *metasternum*. ..... **Emblethis Fieb.**

25(22) Pronotum longer than broad. Scutellum shorter than pronotum. Head longer than broad.

26(27) Joint 1 of antennae surpassing apex of head. Joint 1 of hind tarsi three times as long as joints 2 and 3 combined. ... **Ischnopeza Fieb.**

27(26) Antennal joint 1 terminating at apex of head. Joint 1 of hind tarsi twice as long as joints 2 and 3 combined. ..... **Neurocladus Fieb.**

28(11) Lateral margin of pronotum blunt, or only somewhat sharpened at the slightly narrowed post-median part.

29(48) The two marginal dots (pores) at sternite IV of abdomen separated from each other; posterior porus very close to hind margin of sternite.

30(31) Lateral margin of pronotum blunt, without marginal line. Very small form. ..... **Tropistethus Fieb.**

31(30) Sides of pronotum with well separated marginal line.

32(39) Sides of pronotum only little converging anteriorly.

33(36) Fore femora with numerous teeth within.

34(35) Surface shining, set with conspicuous raised hairs. Fulvous. Membrane not reaching apex of abdomen. Similar to *Anepsiocoris*, especially in coloration, but setae longer. ..... **Allocentrum Bergr.**

35(34) Dark coloured species. Membrane reaching apex of abdomen. .... **Rhyparochromus Curt.**

36(33) Fore femora with only one tooth, or unarmed.

37(38) Pronotum deeply excavated in front, usually broader anteriorly than near base, longer than broad. Median suture of clavus as long as or longer than scutellum. ..... **Plinthisus Fieb.**

38(37) Pronotum with fore margin nearly straight, about as long as broad. Median suture of clavus not one-half as long as scutellum. Somewhat bronze metallic, shining. ..... **Lamprodema Fieb.**

39(32) Sides of pronotum strongly converging anteriorly.

40(43) Fore femora without teeth.

41(42) Anterior portion of pronotum nearly smooth. Body surface shining, clothed with raised hairs. ..... **Lasiosomus Fieb.**

42(41) Anterior portion of pronotum punctured, as is the corium. Surface usually dull. .... **Stygnocoris Dgl. Sc.**

43(40) Fore femora armed with teeth.

44(45) Body without long pilosity. Surface not shining. ... **Peritrechus Fieb.**

45(44) Body surface clothed with raised hairs.

46(47) Antennal joint 3 about one-third longer than 4. Joint 1 of rostrum as long as head. Segment 1 of hind tarsi scarcely twice as long as the two last segments combined. ..... **Anepsiocoris Put.**

47(46) Antennal joint 3 as long as 4. Joint 1 of rostrum shorter than head. Segment 1 of hind tarsi three times as long as the two terminal segments combined. ..... **Lasiocoris Fieb.**

48(29) The two marginal dots on sternite IV much approximated; posterior dot distant from hind margin.

49(54) Head and pronotum with conspicuous punctuation.

50(53) Eyes touching fore margin of pronotum or much approximated to it. Species of moderate size.

51(52) Fore femora with one large and several small teeth, or furnished with fine spines only. Rostrum reaching apex of metasternum. Sides of pronotum not concave, much narrowed anteriorly. **Lethaeus Dall.**

52(51) Fore femora with a small tooth. Rostrum attaining apex of mesosternum. Sides of pronotum concave. ..... **Drymus Fieb.**

53(50) Eyes distant from fore angles of pronotum. Small species. .... **Taphropeltus Stal**

54(49) Punctuation of head and anterior portion of pronotum inconspicuous.

55(56) Body surface dull. Hemielytra not uniformly coloured. .... **Scolopostethus Fieb.**

56(55) Body smooth and shining; brownish. Ocelli wanting. Very small form. ..... **Camptocera Jak.**

Paromius Fieb.

1 (2) Body provided with raised setae, blackish. Membrane dark, veins pale. Length 6.5-7 mm. ..... **leptopoides (Bär.)**

2 (1) Body without raised setae, yellowish brown, head and prothorax darker, anteriorly. Length 7-7.5 mm. ..... **gracilis (Ramb.)**

Paromius gracilis (Ramb.).

Common at Gebel Elba, in the Wadi Aideb and Kansisrob, I-III, on *Gramineae* (leg. H. Priesner)

Paromius leptopoides (Bär.).

Rare. One specimen was taken by Priesner at the light trap, at Mendi (XII).

Pachybrachius annulipes (Bär.).

Rather common under fallen leaves, on the ground between plants, on shrubs and at the lamp. In the Nile valley and in the desert, all over the country and in the Sinai peninsula, all the year.

Marmottania simonis Put.

A desertic species, uncommon. Under and upon stones in the desert valleys east of Cairo and Helwan (I-IV), but also taken at Mex (VI). Predaceous on other insects.

Aegyptocoris myrmecoides China.

(*Proc. R. Ent. Soc. London* (B), 5, 1936, p. 164, fig. 1).

In numbers at the base of grasses ("halfa", but possibly *Panicum turgidum*) at Kafr Hakeem, Magadla, Abu Rowash near Cairo.

Polycrates consutus (Germ.).

Gebel Elba (Wadi Kansisrob, I), under stones; det. W.E. China.

Rhyparochromus praetextatus (H.S.).

Uncommon, in the Delta region and the surrounding deserts, on the ground under *Tamarix* and *Gramineae* (IX-I). Port Said, Menufia Province, Helwan.

Allocentrum Bergroth

1 (2) Pronotum at base nearly twice as broad as long. .... **brevicolle Horv.**

2 (1) Pronotum of female 1.5, of male 1.2 times as broad as long. ..... **heteronotum Put.**

Allocentrum brevicolle Horv.

Sinai (cf. Horváth, *Ann. Soc. Ent. France*, 1914, p. 134); accord-

ing to Bodenheimer's list from Wadi Ain and Wadi Feirân.

Allocentrum heteronotum (Put.).

All the year in the northern coastal area, not rare. Less common in the desert valleys near Cairo and Helwan. Under stones, grasses and *Citrullus colocynthis*.

It may be noted that the pronotum of the male is much broader in front than that of the female.

Tropistethus spec.

A unique specimen taken by Priesner near Alexandria (X) under fallen leaves.

Lamprodema maurum (F.).

Fairly scarce in the cultivated parts of the country and in the deserts. On the ground between grasses and detritus, and at the light trap (VI-XI). A brachypterous form, having the membrane somewhat shortened, was taken at Ikingi (Mariout), Alexandria, Cairo, Giza and Wadi Gerawi.

Plinthisus spec.

St. Katherine (Sinai), under fallen leaves (leg. C. Koch).

(Plinthisus minutissimus Fieb.).

Of Storey's list, may be anything except this species.

Lasiosomus Fieb.

1 (2) Dorsum strongly shining, clothed with numerous long raised setae. Length 4 mm. ..... **enervis (H.S.)**

2 (1) Surface less shining. Setae on dorsum short. Length 3 mm. .... **spec. nov.**

Lasiosomus enervis (H.S.).

Recorded from Egypt (Oshanin, 1912). Not represented in Egyptian collections.

Lasiosomus spec. nov.

A unique specimen, identified by Bergevin with *Allocentrum brevicolle* Horv. belongs, according to W.E. China, to this genus, in which it would rank as a new species.

Mex (VI), coll. Alfieri.

Stygnocoris spec.

Mersa Matrouh (III), under stone (leg. C. Koch).

Peritrechus meridionalis Put.

Under herbs and grasses, at the light, not common (V-XII).

Delta, Giza Province, Canal area (Fayed).

Anepsiocoris encaustus (Put.).

Very scarce, under stones in the desert valleys (I-V, VIII). Widely distributed, desert east of Cairo and Helwan, Wadi Assiouti; Gebel Elba: Sinai.

Aëllopus syriacus (Reut.) (Microtoma syriaca Reut.).

Sinai (St. Katherine) with larvae under *Alcanna tinctoria* (V), leg. H. Priesner.

Raglius aethiops (Dgl. Sc.) (Calyptonotus aethiops Dgl. Sc.).

One specimen was taken at Meadi (V) from the detritus of a small irrigation canal (H. Priesner).

Aphanus Lap.

1 (2) Length 6-7 mm. Head, pronotum in front, scutellum, a rhomboidal spot on corium and a longitudinal spot on membrane, *black*. .... **saturnius (Rossi)**

2 (1) Much smaller. Body ferrugineous and yellow. Legs pale .... **pallidicornis Reut.**

Aphanus (Xanthochilus) saturnius (Rossi).

All specimens (coll. Min. Agric.) are from Giza and Menufia provinces (IX-II), collected on the sand under *Gramineae*.

Aphanus (Liolobus) pallidicornis Reut.

At the coast of the gulf of Suez and the Red Sea (Gebel Ataqa), II, V, VI, XI, on *Cleome droserifolia*. Also taken in the Wadi Isla (Sinai).

Lachnophorus spec.

According to W.E. China, the Egyptian species of this genus is very close to, and possibly a form of, *Lachnophorus singalensis* Dohrn from India (=*guttulatus* Reut. from Madagascar).

Gebel Elba (Wadi Aideb (II)), under stones (leg. Priesner).

Dieuches Dohrn

1 (2) Head, pronotum and scutellum dull black; fore femora dark, middle and hind femora yellow about basal half. Corium whitish yellow, a transverse band and membrane black, with two white spots. Slender species. ..... **syriacus Dohrn**

2 (1) Pronotum not so dark.

3 (4) Very slender species. Fore femora shaded with brown, middle and hind femora darkened at apices. Antennal 1 shorter. Membrane dark. ..... **armipes (F.)**

4 (3) Less slender. Legs pale. Antennal 1 longer. Membrane not wholly dark. ..... **mucronatus (Stal)**

Dieuches mucronatus (Stal).

In the desert and on sandy places of the north and the Nile valley, all the year, under stones and *Citrullus colocynthis*, and (seldom) at the lamp. Sinai; Gebel Elba.

Dieuches syriacus Dohrn.

Uncommon (III-VIII, XII). Meadi (at the lamp), Helwan (Wadi Gerawi, Wadi Umm-Elek, under *Citrullus colocynthis;* Sinai (El-Areesh, Tayiba, Gederât).

Dieuches armipes (F.).

Assiout (teste Costa); Gebel Elba (Wadi Aideb, II, III), leg. H. Priesner.

Ischnopeza pallipes Put.

In the northern coastal area (Borg-el-Arab, Dabaa, III, VI, VIII, X, XI), under stones, occasionally. One specimen was taken at Marg near Cairo (II). Identification confirmed by W.E. China.

Emblethis Fieb.

1 (8) Joint 1 of hind tarsi distinctly more than twice as long as joints 2 and 3 combined, longer than antennal joint 3. Fore angles and margin of pronotum without conspicuous raised black spines.

2 (3) Sides of pronotum in posterior two-thirds parallel or nearly so, comparatively much rounded anteriorly. ..... **verbasci (F.)**

3 (2) Pronotum more distinctly trapezoidal, not parallelsided in posterior third.

4 (5) Spines on antennal joint 2 long (as in *verbasci*) some of them distinctly longer than width of joint 1. Sides of pronotum converging from base to middle, somewhat convex from middle to apex, pronotum somewhat less transverse. Membrane reaching apex of abdomen. ... . **angustus Mont.**

5 (4) Spines on antennal joint 2 shorter, not or hardly longer than width of joint 1. Sides of pronotum strongly tapering from base to apex.

6 (7) Larger. 5.5-6.5 mm. Legs and antennae long and slender, antennal joint 3 about as long as pronotum at middle or little shorter. Membrane of female not reaching apex of abdomen. ..... **gracilicornis Put.**

7 (6) Smallest species, 4.3-4.6 mm. Legs and antennae normal, joint 3 of antennae much shorter than pronotum at middle. Membrane reaching apex of abdomen in both sexes. ..... **pusillus spec.nov.**

8 (1) Joint 1 of hind tarsi scarcely twice as long as joints 2 and 3 combined; if longer, margin of pronotum with a submarginal (dorsal) row of black spines.

9(10) Margin of pronotum with a row of black spines which surpass the margins for about half their length. Antennals 2 and 3 with stout bristles. Very broadly and shortly built species with margin of pronotum and corium broad. ..... **ciliatus Horv.**

10 (9) Margin of pronotum without conspicuous spines. Bristles on antennae shorter and of more even length, not nearly vertically raised.

11(12) Lateral margin of pronotum behind fore angles with a short lamelliform projection on under side. Length 5-6 mm. .... **denticollis Horv.**

12(11) Lateral margin of pronotum without projection on under side.

13(14) Lateral margin of pronotum swollen on under side. .... **bullatus Fieb.**

14(13) Lateral margin of pronotum flat, lamelliform. ..... **griseus (Wolff).**

Emblethis gracilicornis Put.

Some specimens from Abu Zabal and Khanka (II), in coll. Alfieri and coll. Fouad I Entomological Society. Det. W.E. China.

Emblethis verbasci (F.).

Practically all over the country, common; on the ground, under detritus of *Tamarix, Gramineae* and decumbent plants *(Zygophyllum, Citrullus)*, borders of desert, uncultivated or waste places, all the year.

Emblethis angustus Mont.

Common like *verbasci* and on the same localities. Probably not specifically different.

Emblethis ciliatus Horv.

Widely distributed (Matrouh, Delta, Giza Province), but uncommon, under *Gramineae*, practicaly the whole year. Det. W.E. China.

Emblethis denticollis Horv.

One specimen, Meadi (VI), at the lamp (H. Priesner).

Emblethis bullatus Fieb.

Together with *griseus* (Wolff), and probably not specifically different; less numerous, all the year. No record, as yet, from the coastal regions. Southermost record: Luxor.

Emblethis griseus (Wolff).

The most common species of the genus, on the same biotops as *verbasci*, all the year, south to Giza Province, Fayoum, but most likely all over Upper Egypt, too.

Emblethis pusillus spec. nov.

Ikingi (Mariout), 23.VIII.1934, leg. A. Rabinovitch.

(Gonianotus barbarus Mont.).

This species is mentioned from Suez, but most likely *Emblethis gracilicornis* was meant.

Lethaeus Dall.

1 (2) Larger, 8-9.5 mm. Dark brown. Pronotum broad. Fore femora at apex within with a few densely set spines of unequal length .... **fulvovarius Put.**

2 (1) Smaller, at most 7 mm. Pronotum narrower. Fore femora with a few scattered raised bristles ..... **lethierryi Put.**

Lethaeus fulvovarius Put.

This species was taken only at the light trap at Meadi, and at Marg and Zeitoun (III-VIII). It is not common.

Lethaeus lethierryi Put.

Coastal region, from Salloum to Amriah. A few records from the Nile valley (Giza, Helwan). It lives under stones, occasionally in associations (I-X). Common in the valleys of Gebel Elba (I-III); Sinai (IV).

Drymus assimilis Horv.

Oshanin (1912) records it from Egypt.

Scolopostethus decoratus (Hahn.).

Recorded from Egypt by Oshanin (1912), but, like the above species, not represented in any Egyptian collection.

Taphropeltus spec. nov.

Gebel Elba (Wadi Rabdeit, I), rare. Det. W.E. China.

Camptocera angustula Put.

From Salloum to Asswan, common under stones and decumbent plants (III-XI); the macropterous form we occasionally found at the lamp. Identification confirmed by R.J. Izzard.

7. Family BERYTIDAE Fieb. (Neididae Reut.).

Key to genera

1 (2) Scutellum without dorsal spine. Venter with coarse punctuation .... **Berytinus Kirk. (Berytus F.)**

2 (1) Scutellum with dorsal spine. Venter without coarse punctuation .... **Triconulus Horv.**

Berytinus Kirk.

1 (2) Larger, 9.5-10.5 mm. Antennal joint 1 with raised bristles. Membrane pointed at apex ..... **hirticornis (Brullé)**

2 (1) Smaller, at most 6.5 mm. Antennae without raised setae. Membrane rounded at apex. ..... **brevicornis Horv.**

Berytinus hirticornis (Brullé).

Menufia, Cairo, Helwan, uncommon under halfa grass, *Panicum* (VIII-I).

Berytinus brevicornis Horv.

Always under *Gramineae*, especially *Panicum turgidum*, and under *Tamarix*; once in a sparrow's nest. All over the Delta and in Giza Province, sometimes at the lamp (III-XII). Det. K. Schmidt.

Triconulus aegyptius Horv.

Rather rare and easily overlooked. On waste land, in gardens and in the desert. Delta and Canal Zone.

8. Family PIESMIDAE A.S.

Only genus : *Piesma* L.S.

Piesma capitata (Wolff).

Recorded by Oshanin (1912), and Horvárth (1916), but not existing in Egyptian collections. It is common in Europe.

9. Family TINGIDAE Costa

Key to genera

1 (2) Clavus distinctly developed (*Cantacaderinae* Stal). ... **Cantacader A.S.**
2 (1) Clavus completely fused with corium.
3(26) Marginal (seldom wanting), lateral and central areas of hemielytra distinctly differentiated (*Tinginae* Stal).
4 (7) Genal plates incised in front.
5 (6) Body with vesicle-like formations on dorsum. ..... **Galeatus Curt.**
6 (5) Body without dorsal vesicles but with numerous spines. ..... **Urentius Dist.**
7 (4) Genal plates nearly closed in front, not deeply incised.
8(23) Pronotum with three longitudinal carinae.
9(20) The membraneous lateral margin of the pronotum simple, or more or less broadly expanded horizontally, not reflexed and not forming an elongate lateral reticulated callus.
10(11) Antennal joints 3 and 4 very strongly incrassate, antennae therefore clavate. ..... **Copium Thnbg.**
11(10) Antennae normal.
12(13) Central and lateral area of corium strongly convex anterior to middle. ..... **cf. Stephanitis Stal**
13(12) Central and lateral area of corium not or slightly convex anterior to middle.
14(15) The median convexity of the anterior portion of the pronotum nearly reaching apex of head. ..... **Elasmotropis Stal**
15(14) This anterior median part of the pronotum never surpassing eyes.
16(17) Lateral margins of pronotum, or at least of hemielytra, set with spines or bristle-bearing teeth. ..... **Lasiacantha Stal**

17(16) Lateral margins without spines or bristle-bearing teeth.
18(19) Anterior half of marginal area of corium composed of one row of small cells of equal size. Sternal carinae not elevated. ..... **Compseuta Dist.**
19(18) Cells of marginal area of corium arranged in one or two rows, but cells irregular in size. Sternal carinae more or less elevated. ..... **Tingis F.**
20 (9) Pronotum not margined laterally, and not expanded horizontally, but with an elongate, reticulated callus, on either side.
21(22) Orifices of odoriferous glands prolonged into a fine furrow or stria. ..... **Monanthia L.S.**
22(21) These orifices prolonged into a narrow groove. Colour ferrugineous. ..... **Physatochila Fieb.**
23 (8) Pronotum with only one longitudinal carina.
24(25) Margin of pronotum and marginal area of corium distinctly differentiated. Very small species. ..... **Monostira Costa**
25(24) Margin of pronotum marked only by an obsolete keel, marginal area of elytra wanting. ..... **Ceratinoderma Stal**
26 (3) Marginal, central and lateral area of hemielytra not distinctly differentiated. Slender forms (*Serenthiinae* Stal). ..... **Serenthia Spin.**

Cantacader quadricornis (Le P.S.).

With var. *nubilus* Horv. (V-VII, X), rather rare, usually found at the lamp. Pyramids of Giza, Meadi, Helwan.

Galeatus scrophicus Saund.

Always in the flower heads of *Echinops spinosa*.

Delta, and deserts near Cairo, the Pyramids of Giza; Helwan, Kena, Asswan (V-IX); Sinai.

Urentius Dist.

1 (2) Larger species, 2.5-2.7 mm., always with two rows of marginal cells of corium. Spines shorter than width of margin. **aegyptius Bergevin**
2 (1) Smaller, 2-2.3 mm. Corium with only one row of marginal cells, which is doubled to two or three cells at base only. Spines as long as or longer than width of margin. ..... **abutilinus spec. nov.**

Urentius aegyptius Bergevin

Sometimes very numerous, even damaging its host plant : *Solanum melongena*.

Upper Egypt (Kom Ombo, Asswan), summer and autumn.

Urentius abutilinus spec. nov.

Upper Egypt, in April, on *Abutilon muticum* (leg. Priesner).

Elasmotropis testacea (H.S.).

This species occurs in the north : Alexandria, Montaza and elsewhere along the coast, on the coastal dunes in *Echinops* heads (V-VII). Its varieties may be separated as follows :

1 (2) Pronotum less than twice as wide as the length of antennal joint 3. ..... **testacea typ.**

2 (1) Pronotum more than twice as wide as length of antennal 3.

3 (4) Lateral area of corium with three irregular rows of cells. ... . **vicina Horv.**

4 (3) Lateral area of corium with two regular rows of cells, narrower in front. ..... **f. egena Put.**

Lasiacantha spec. nov.

Gebel Elba (Wadi Kansisrob, I.). Det. Izzard.

Tingis F.

1 (6) Margin of prothorax broad, at least with one row of cells.

2 (5) Margins and carinae of pronotum and corium with raised hairs which are longer than the diameter of an eye. ..... **Subg. Lasiotropis Stal**

3 (4) Dorsum and margins pilose. Antennal joints 2-3 yellowish. Anterior vesicula of pronotum convex. Venter pale. ..... **rotundipennis Horv.**

4 (3) Dorsum without raised hairs. Antennal joints 1 and 2 dark, 3 yellowish. Vesicula of pronotum horizontal, in lateral aspect. Venter dark. ..... **denudata Horv.**

5 (2) Margins and carinae of pronotum and corium bare, or with hairs that are shorter than the diameter of an eye. ..... **Subg. Tingis s.str.**

6 (1) Lateral margin of pronotum narrow, somewhat reflexed. Elongate species. ..... **Subg. Tropidochila Fieb.**

7 (8) Elytra much broader than prothorax. Tip of discoidal area near apex of wing ; membraneous part of corium not developed. Length not exceeding 3 mm. ..... **liturata (Fieb.)**

8 (7) Elytra little broader than prothorax. Tip of discoidal area far apart from apex of elytra. Membrane well developed, long. Length about 3.5 mm. ..... **aegyptiaca Pries.**

Tingis (Lasiotropis) rotundipennis Horv.

On dry biotopes (V-VII), common with its early stages on *Echinops spinosa*, in the desert as well as among cultivations, on dunes or sandy places.

Tingis (Lasiotropis) denudata Horv.

Recorded from Egypt, but unknown to us.

Tingis (Tropidochila) liturata (Fieb.).

From Ikingi and Abukir (VI-VIII), but most likely occurring all over the northern Mediterranean belt. Once from the Giza Pyramids (I). Det. K. Schmidt.

Tingis (Tropidochila) aegyptiaca Pries.

(*Bull. Soc. Fouad I Ent.*, XXXV, 1951, pp. 138-139).

A rare species, known from Cairo and Wadi Nouega (Galala), V, VI (coll. Alfieri).

Copium teucrii (Host).

A single specimen taken by Rabinovitch (coll. Alfieri) at Ikingi (Mariout), in VIII. The specimen is slightly different from European specimens of *teucrii* in having lateral area of elytra with 2 to 3 rows of cells only, and the elytra paler than in the typical form. Host plant unknown but may be *Teucrium polium*.

Physatochila dumetorum (H.S.).

Recorded from Egypt (Oshanin, 1912) but not represented in our collections.

Compseuta montandoni Dist.

Gebel Elba (Wadi Rabdet), common with larvae in January on *Triumfetta flavescens* (*Labiatae*). Det. W.E. China.

Monanthia L.S.

1 (2) Length 3-3.75 mm. Antennal joint 3 about three times as long as 4. Lateral area of corium with three rows of cells. ..... **nassata Put.**

2 (1) Length 2.5-3 mm. Antennal joint 3 shorter, at most 2.6 times as long as joint 4. Lateral area of corium with two or three (var. *pulla* Horv.) rows of cells. ..... **putoni Mont.**

Monanthia nassata Put.

In great numbers chiefly on the coastal dunes of the northern belt, Alexandria and Mariout, but also near Cairo, all the year on *Echium sericeum* and most likely on other *Echiums*.

Identification confirmed by W.E. China.

Monanthia putoni Mont. var. pulla Horv.

Some specimens from Mansura and Montaza (VI-VII). Det. Lindberg.

Monostira Costa

1 (4) Colour nearly wholly black, only the dorsal carinae yellow. Base of head unarmed. Discoidal area of corium without cross-vein. 2-2.5 mm. Subgen. *Phaenotropis* Horv.

2 (3) Legs wholly dark. Pronotal carinae pale. ..... **cleopatra Horv.**
3 (2) Tibiae reddish at middle. Shorter form. Keels of pronotum less prominent. ..... **spec. nov.**
4 (1) Body partly yellowish. Head furnished with spines. Discoidal area of corium with cross-vein. Subgen. *Monostira*, s.str.
5 (6) Pronotum with a lobe-like expansion behind anterior angles. Corium somewhat depressed. On *Salix* spp. ..... **lobulifera Reut.**
6 (5) Pronotum without lobiform lateral expansion.
7 (8) Scutellum shorter, pronotum more deeply yellow. Corium at bifurcation of veins triangularly elevated. On *Zizyphus*. .. **minutula Mont.**
8 (7) Scutellum longer. Pronotum pale. On *Indigofera* sp. ..... **spec.**

Monostira lobulifera Reut.

Locally in numbers on leaves of *Salix* spp.
Cairo (VI-VII); Sinai (Umm-Mitla).

Monostira minutula Mont.

Cairo, Kharga (IV-VIII), on *Zizyphus spina-christi*, and at the lamp.

Monostira spec.

A unique specimen taken south of Asswan on *Indigofera* sp. (IV), leg. Priesner.

Monostira (Phaenotropis) cleopatra Horv.

Rare. In the autumn, under *Panicum turgidum*, but most likely accidentally, the real host plant unknown. Cairo-region.

Monostira (Phaenotropis) spec. nov.

One specimen from Abu Simbil (IV), leg. Priesner.

Serenthia atricapilla Spin. f. pallens Horv.

From El-Wasta and Oasis Kharga (III), taken from *Gramineae*. Det. Lindberg. W.E. China considers our Egyptian *Serenthia* a new species near *dubia* Horv.

Ceratinoderma spec.

Wadi Nouega (Galala), V, on *Gymnocarpus decander* (coll. Alfieri). Det. W.E. China.

10. Family JOPPEICIDAE Reut.

Only genus : *Joppeicus* Put.

Joppeicus paradoxus Put.

Everywhere in the Delta and the deserts, not rare, occasionally abundant under fallen leaves, detritus of desert shrubs or under bark of *Ficus sycomorus* and *Acacia nilotica*. All over the country, all the year.

11. Family REDUVIIDAE Latr.

Key to genera

1(10) Fore coxae very long, cylindrical, surpassing apex of head, inserted at fore margin of prosternum. Legs fine, filiform. .... *(Subfam. Emesinae A.S.).*

2 (5) Scutellum with spine.

3 (4) Segments of connexivum without apical thorn. Body without prominent hairs. ..... **Empicoris Wolff (Ploiariola Reut.)**

4 (3) Segments of connexivum with blunt or pointed production apically. Body and legs with long, very fine, raised hairs. ... **Stenolemus Sign.**

5 (2) Scutellum without spine.

6 (7) Fore femora with a conspicuous spine about middle, spinulose from middle to apex. Fore tibiae about one-half as long as femora. Fore tarsi one-segmented with one long claw. ..... **Ghilianella Spin.**

7 (6) Fore femora without median spine. Fore tarsi three-segmented.

8 (9) Fore femora all along with a dense row of fine, bristle-bearing spines. Fore trochanter with spine-like production and bristle. Hemielytra wanting, at least in the female. ..... **Ploiaria Scop.**

9 (8) Fore femora with a row of rigid bristles. Fore trochanter without spine, only with bristle. Hemielytra fully developed in both sexes. ... . **Lethierrya Put.**

10 (1) Fore coxae normal, usually conical, not surpassing apex of head, and not inserted at fore margin of prothorax.

11(28) Antennal joint 1 shorter than joint 2.

12(13) Antennae and legs densely clothed with plumose setae. Female with hemielytra much reduced, larvoid in aspect. Small species (Subfam. *Holoptilinae* Stal). ..... **Dasycnemus Bergr.**

13(12) Antennae and legs without plumose setae.

14(19) Hemielytra between membrane and corium with a large cell. Fore femora with spines (Subfam. *Stenopodinae* Stal).

15(16) Inferior face of head spinulose. Fore femora with two rows of conspicuous spines. ..... **cf. Sastrapada A.S.**

16(15) Under side of head unarmed.

17(18) Eyes pilose, strongly protruding. Segment 1 of rostrum longer than 2. Antennae with exceptionally long and abundant setae. Internal cell of membrane without transverse subbasal vein. ..... **Stirogaster Jak.**

18(17) Eyes bare, less protruding. Segment 1 of rostrum shorter than 2. Internal cell of membrane with transverse subbasal vein which forms a quadrate cell. ..... **Oncocephalus Klug**

19(14) Hemielytra between membrane and corium with a *small* cell at the most. Fore femora unarmed.

20(23) Metasternum without carina, somewhat produced in front (Subfam. *Piratinae* Stal).

21(22) Appendages of fore tibiae short, attaining one-half of length of tibiae at the most. ..... **Pirates Serv.**

22(21) Appendagees of fore tibiae long, occupying more than half the length of the tibia. Posterior part of prothorax only two-fifths of anterior portion, the latter without median longitudinal line. .... **Ectomocoris Mayr**

23(20) Metasternum with longitudinal carina, not produced in front. Female sometimes with hemielytra reduced. ..... *Subfam. Reduviinae Reut.*

24(25) Fore tibiae without lamelliform appendage. Eyes smaller. .... **Holotrichius Burm.**

25(24) Fore tibiae, at apex, with lamelliform appendage. Eyes large.

26(27) Length less than 10 mm. Antennal joint 1 not very long. .... **cf. Pasira Stal**

27(26) Size above 15 mm. Antennal 1 long. ..... **Reduvius F.**

28(11) Antennal joint 1 longer than 2 (Subfam. *Harpactorinae* Reut.).

29(32) Body very long and slender, sometimes phasmoid. Cinereous.

30(31) Apterous. Body extremly slender, phasmoid ..... **Rhaphidosoma A.S.**

31(30) Macropterous. Elongate, but not phasmoid ..... **Vibertia Horv.**

32(29) Body normal; if slender, not cinereous in colour; never phasmoid in shape.

33(36) Mesosternum laterally, towards hind margin of prosternum, with a tubercle or small fold. Femora unarmed.

34(35) Body much elongate, collum very long, head slender, with one or two spines anteriorly. ..... **Nagusta Stal**

35(34) Body not very slender. Head normal, without long neck, unarmed. ... . **Coranus Curt.**

36(33) Sides of mesosternum without any tubercle or fold, anteriorly.

37(42) Claws unarmed.

38(39) Prothorax furnished with two rows of spines. Body slender. Antennae moderately long. ..... **Vachiria Stal**

39(38) Prothorax without rows of spines. Body much less slender. Antennae shorter.

40(41) Femora smooth. Ocelli not on elevated tubercles. .. **Amphibolus Klug**

41(40) Femora nodose before apex. Ocelli situated on tubercles. Hind femora much elongate. ..... **Paramphibolus Reut.**

42(37) Claws with tooth or appendage.

43(44) Scutellum much widened posteriorly, lobiform, this posterior part concave or reflexed. ..... **Cosmolestes Stal**

44(43) Scutellum nor or only slightly widened apically, not or only slightly concave or bent upwards.

45(46) Longitudinal furrow of anterior lobe or pronotum attaining transverse impression, more or less extending also onto posterior lobe. ..... **Sphedanolestes Stal**

46(45) Impression of anterior lobe of pronotum not reaching transversal structure. ..... **Rhinocoris Hahn**

Empicoris Wolff

1(12) Fore femora with spines.

2(11) Antennae and femora with black and white rings.

3 (6) Connexivum unicolorously pale or with small black dot on each segment. Antennae and femora white with dark rings. Length 6-7 mm.

4 (5) Connexivum unicolorous. Antennae and legs not quite smooth. Length 7 mm. ..... **cf. vagabunda L.**

5 (4) Connexivum with small black dot on hind angles of segments. Antennae and legs quite smooth. Length 5.5-6 mm. ..... **soror Put.**

6 (3) Connexivum dark with large black basal spot on each segment or nearly wholly dark. Antennae and femora brown with white rings.

7(10) Posterior part of pronotum with spine.

8 (9) Pronotal spine rather long, straight, evenly wide, erect. Segments of connexivum black, scarcely spotted with yellow. ..... **cf. baerensprungi Dohrn**

9 (8) Pronotal spine very short, conical with broad base. Segments of connexivum with large, rectangular, yellow spot. ..... **cf. brevispina Put.**

10 (7) Posterior portion of pronotum without spine. Length 4.5 mm. ..... **culiciformis Deg.**

11 (2) Femora and antennal joint 1 with a brown ring at apex. Hemielytra reaching only to segment III of abdomen. Fore femora, pale at base and apex. Length 4 mm. ..... **cf. uniannulata Sign.**

12 (1) Fore femora without spines Black, on each connexival segment a white dot. Antennae brownish with pale rings, middle and hind legs with pale and dark rings. Length 3.5 mm. ..... **cf. xambeui Mont.**

Empicoris soror (Put.).

Uncommon but widely distributed (I, VI, VII, X), Helwan, Kerdasa, Mansuria, Ikingi.

Empicoris brevispina (Put.).

This and other species dealt with in the above key may occur in Egypt, but hitherto we have no sure record.

Stenolemus Sign.

1 (2) Length (inclusive of hemielytra) 13-14 mm. Pedicel of pronotum at least twice as long as anterior lobe, the latter with sides straight or convex. ..... **macrostylus Horv.**

2 (1) Length 8-9 mm. Pedicel of pronotum about as long as anterior lobe or shorter; sides of lobe slightly concave.

3 (4) Head distinctly broader than long, depressed above; transverse cephalic groove situated between eyes, the latter much protruding. Joints 1 and 2 of rostrum strongly incrassate. ..... **laticeps Horv.**

4 (3) Head as long as broad, strongly convex, dorsally; transverse groove deep, somewhat posterior to eyes. Eyes less protruding. Joints 1 and 2 of rostrum less incrassate. ..... **novaki Horv.**

Stenolemus macrostylus Horv.

Type from Shoubra (VII), coll. Alfieri. This interesting insect was not found since.

Stenolemus laticeps Horv.

Giza, Meadi, Massara (I-IX, XII); Upper Egypt. This species was repeatedly taken at the light trap. It is a predator of small insects, its habits are nocturnal.

Stenolemus novaki Horv.

We only know two specimens from Egypt, i.e. from Gebel Asfar and the Pyramids of Giza (VIII, IX). Rabinovitch found it under *Panicum turgidum*.

Ghilianella spec.

A unique specimen from Asswan (IV), leg. K.J. Hayward (coll. Min. Agric.).

Lethierrya biskrensis Put.

Rare. Pyramids (Sakkara Road), under clods of soil during the Nile flood (X). Assiout, Oasis Dakhla, at the lamp (III, X, XII).

Ploiaria Scop.

1 (2) Large species, 9-10 mm. Head only slightly narrowed towards base. ..... **grassator (Put.)**

2 (1) Smaller, 5.5-6 mm. Head strongly narrowed towards base. ..... **gutturalis Noualh.**

Ploiaria grassator (Put.).

Not common. Cairo, Pyramids of Giza, Kerdasa, Meadi, Dendera, Oasis Siwa. On the ground, under stones and most likely in caves (I, II, VIII, X-XII).

Ploiaria gutturalis Noualh.

Amriah, Giza Pyramids, Abu Rowash, Wadi Digla, occasionally. May not be rare but is easily overlooked (VI, IX-II).

In Alfieri's collection there is a couple of winged males which may belong to *gutturalis*.

Oncocephalus Klug. ([8])

1(22) Fore tibiae with dark rings.
2(17) Fore femora within with one row of fine teeth or spines.
3 (8) Hind femora only at apex with dark spot. Discal, or also apical, cell of hemielytra with brown velutinous spot.
4 (7) Hind angles of pronotum protruding and pointed. Tubercles of anterior lobe of pronotum large, raised. Antennae yellow, with long pale hairs.
5 (6) Antennal joint 2 twice as long as joint 1. (Length of elytra varying, but membrane, though short, developed in the brachypterous form). Length 15-17 mm. (Algeria). ..... **cf. acutangulus Reut.**
6 (5) Antennal joint 2 more than twice as long as joint 1, the latter straight. Brachypterous. Length 16 mm. (Algeria, Morocco). .... **cf. vosseleri Reut.**
7 (4) Hind angles of pronotum not protruding, angularly rounded. Tubercles of anterior lobe of pronotum small, rounded, little elevated. Much elongate, grey-brown, with three consecutive, dark, longitudinal spots on corium + membrane. Length 12-18 mm. ... **pilicornis (H.S.)**
8 (3) Hind femora with dark spot at apex and, in addition, with one or two dark rings.
9(16) Head and pronotum smooth, or small species.
10(15) Segment 1 of rostrum longer than 2 or at least of the same length.
11(12) Length 9.6 mm. Anterior portion of head little longer than posterior one. Macropterous ..... **trochantericus Bergr.**
12(11) Length 11-13 mm.
13(14) Anterior portion of head equalling posterior one. Usually macropterous. Length 12-13 mm. (Algeria, Tunisia). ..... **cf. putoni Reut.**
14(13) Anterior lobe of head one and one-half times as long as posterior lobe.. Brachypterous. Length 11-13 mm (Algeria, Tunisia). .... **cf. curtipennis Reut.**
15(10) Segment 1 of rostrum distinctly shorter than segment 2. Corium yellow at base, with an ill-defined cross-band in posterior part. Prono-

([8]) Key partly after Dispons, P.: Révision des *Oncocephalus* de l'Afrique du Nord (*Rev. Franç. d'Ent.*, XVII, 1950).

tum for the greater part yellow, posteriorly with dark longitudinal lines, the median of which being forked. Sides of pronotum strongly concave. Fore trochanter without process. Length 11-16 mm. .... **obsoletus Klug**

16 (9) Head and pronotum with small, setiferous granules. Hemielytra without dark spots. Scutellum with yellow median line attaining apex. Fore trochanter unarmed. Length 11-16 mm. .....**squalidus (Rossi)**

17 (2) Fore femora with two rows of spiniferous tubercles.

18(21) Head with brown lines, posteriorly. Scutellum yellow. Pronotum with faint brown striae on anterior lobe. Fore trochanter with a small rounded projection.

19(20) First antennal joint as long as or a little longer than anterior portion of head. Fore femur with 6 or 7 spines and some smaller ones, irregularly placed. Length exceeding 10 mm. ..... **notatus Klug.**

20(19) First antennal joint shorter than anteocular part of head. Fore femora with 10 spines in a single row. Length 9.6 mm. .... **cf. trochantericus Bergr.**

21(18) Head with a shining black roundish spot on posterior part. Three black interrupted bands on anterior lobe of pronotum and four black bands on posterior lobe. Scutellum fulvous, with sides and apex pale. Length 10.5 mm. (Algeria). ..... **cf. fokkeri Horv.**

22 (1) Fore tibiae without dark rings, or at most with very faint dark spots.

23(24) Body and legs wholly yellow, without dark spots. Length 10.5 mm. (Algeria, Tunisia). ..... **cf. vaulogeri Mont.**

24(23) Body (and sometimes also legs) with dark markings.

25(26) Pronotum without lateral tubercle, hind angles not sharp. Constriction of pronotum just behind middle. Elytra (male) yellow, with a brown band posteriorly. Pronotum with dark longitudinal bands. Connexivum with a more or less large brown spot at middle of each segment. Femora with pale-brown rings. Fore femora with 10 small spines. Often brachypterous. 8-12 mm. (North Africa). ... **cf. fasciatus Reut.**

26(25) Pronotum, at sides, with a conspicuous tubercle in front of basal constriction. Hind angles of pronotum pointed. Brachypterous female with wing pads only somewhat surpassing apex of scutellum. Constriction of pronotum in posterior third. ..... **variegatus Reut.**

Oncocephalus pilicornis (H.S.).

Not rare at the light. All over the Delta, Giza Province, Canal Zone and at the northern coast (IV-XII).

Oncocephalus obsoletus Klug.

Widely distributed, but not common. Recorded from Salloum, Upper Egypt (Esna, Luxor, Kom Ombo, Oasis Dakhla), under stones and at the

lamp (III-V). Det. E.W. China. Lindberg gave the name *impictipes* Stal to this species.

Oncocephalus squalidus (Rossi).

At the lamp and under detritus, in the Delta, Giza Province, Canal Zone and the oases. Not common, the whole year.

Oncocephalus notatus Klug.

Cairo and Giza province, always taken at the lamp (IV-IX). Not rare at Meadi.

Oncocephalus trochantericus Bergr.

Type specimen collected by L.H. Gough at Meadi. The insect was not found since.

Oncocephalus variegatus Reut.

Ikingi, Hammam, Mex (III-IV), under stones, females only. Det. R.J. Izzard.

Note: Costa mentions *Oncocephalus annulipes* Stal from Fayoum and Edfu, but these records most likely concern *O. obsoletus* Klug.

Stirogaster spec.

According to W.E. China this species comes near *St. desertorum* Kiritsch.

Oasis Dakhla (V), leg. Storey (coll. Min. Agric.); Sinai (Wadi Isla) (IV), coll. Alfieri.

Dasycnemus sahlbergi Bergroth.

Desert and Delta, male uncommon on plants (e.g. *Crozophora*) and at the lamp, the apterous female and the larvae under stones (II-VIII). A larva was kept for three months without food and finally developed into a female (V).

Holotrichius Burm.

1 (6) Males (macropterous).
2 (5) Length 20-25 mm. Pronotum dark.
3 (4) Legs pale, with tips of femora and extreme base and apex of tibiae brownish. Pronotum shining, pronotal calli longer. Anterior portion of head longer than postocular one. Femora stouter. .... **laevigatus Reut. (henoni Put.)**
4 (3) Legs dark brown. Pronotum dull, calli very short. Anterior portion of head not longer than collar part. Femora very slender. .... **luctuosus (Mls. and Mayet)**
5 (2) Lengh not over 12 mm. Pronotum with anterior lobes pale. Femora

yellowish with two dark rings, tibiae dark at extreme base and with a broad postbasal ring. ..... **spec. nov.**

6 (1) Females (subapterous).

7 (8) Longest raised hairs on joint 2 of antennae as long as eye or little shorter. Hind tibiae with long, raised hairs. .... **laevigatus Reut. (innesi Horv.)**

8 (7) Longest raised hairs on joint 2 of antennae distinctly shorter than eyes' diameter. Hind tibiae with shorter, spine-like setae. .... **luctuosus (Mls. and Mayet)**

Holotrichius laevigatus Reut. (henoni Put., innesi Horv.).

Males under stones and at the lamp, females in the sand (e.g. under *Citrullus*) at the borders of or in the desert or also under stones or clods of earth. Helwan, Massara, Wadi Zuleika, Wadi Digla, Fayed, Suez (III, VIII, IX). *H. innesi* Horv. is the female of this species.

Holotrichius luctuosus (Mls. and Mayet).

Abusir, Mex, Sidi Bishr, Mergheb (IV, V, VIII); f. *fuscescens* Reut. refers to brownish specimens, whereas the typical form is brownish black.

Holotrichius spec. nov.

Gebel Elba (I), males only. This species was examined by W.E. China.

Reduvius F.

1 (2) Body wholly dark blackish brown. Legs yellowish, femora with a large and a small dark ring apically. ..... **nigricans (Klug)**

2 (1) Body not wholly blackish brown.

3 (8) Corium with a dark cross-band posteriorly.

4 (7) All legs wholly pale.

5 (6) Larger, 16-17 mm. Prothorax shining. Transverse band of corium not united with clavus; corium broadly yellow behind scutellum. .... **pallipes (Klug)**

6 (5) Smaller, 11.5-14 mm. Prothorax dull. Corium dark from apex of scutellum to cross-band. ..... **jakovlevi Reut.**

7 (4) Hind femora with pre-apical brown ring. Dark part of clavus and cross-band of corium united by a dark longitudinal band. Wing pads of brachypterous female yellowish. The yellow base of the abdomen horse-shoe-shaped. ..... **tabidus (Klug)**

8 (3) Corium without distinct cross-band, at most angles of corium dark

9(12) Body and legs densely clothed with raised hairs.

10(11) Larger species, about 12 mm. in length. ..... **nebulosus (Klug)**

11(10) Smaller, 6-7 mm. Hairs longer. ..... **spec. nov. near minutus Reut.**

12 (9) Body and legs not clothed with long hairs. Tip of corium and base

of membrane darkened longitudinally. Pronotum ferrugineous. Fore and middle femora with row of fine teeth. ..... **armipes Reut.**

Reduvius nigricans (Klug).

Recorded from Egypt (Oshanin, 1912), but not represented in our collections.

Reduvius nebulosus (Klug).

Middle and Upper Egypt, at the lamp and under detritus (V-X).

Reduvius dorsalis Stal.

Perhaps identical with *tabidus* Klug.

Reduvius pallipes (Klug).

Not rare at the light (IV-XII), in the Delta and in Upper Egypt; Mariout, Canal Zone, Red Sea coast.

Reduvius tabidus (Klug).

Mersa Matrouh, Sinai (VI, VII); Gebel Elba (I-III).

Raduvius jakovlevi Reut.

Not rare at the lamp (III-XI). Cairo, Upper Egypt, Sinai. Gebel Elba (I). A desertic species.

Reduvius armipes Reut.

Wadi Abrag, Mersa Halaib, Gebel Elba (I).

Reduvius spec. nov.

Meadi, Helwan, Kharga, at the lamp (VI-VIII). Was formerly identified as *minutus* Reut.

Note: Other previous records on species of this genus are doubtful. The genus is being revised by N.C.E. Miller (London).

Ectomocoris Mayr

1 (2) Black, with a large whitish spot at interior angle of corium. .... **fenestratus (Klug)**

2 (1) Elytra and legs fulvous.

3 (6) Posterior part of pronotum fulvous.

4 (5) Antennal 3 shorter than 2, joint 4 hardly half as long as 3. Spongy furrow of fore tibiae about half as long as the latter. **ochropterus Stal**

5 (4) Antennals 2 to 4 of about equal length. Spongy furrow on fore tibiae nearly reaching base of tibia. ..... **luridus Klug**

6 (3) Pronotum wholly dark. ..... **ululans (Rossi)**

Ectomocoris ululans (Rossi).

Widely distributed in the cultivated area, in damp localities. During the Nile flood in soil crevices of canal banks; the insect is a good swimmer. Occasionally at the lamp, even in the centre of Cairo (III-XII); Sinai.

Ectomocoris luridus (Klug).

Like the former, but more common (V-XI). Delta and Upper Egypt.

Ectomocoris fenestratus (Klug).

Ethiopic species, of which a perfect specimen was taken in the oasis Kharga (III) by Moh. Kassim.

Ectomocoris ochropterus Stal (posticus Walk.).

Recorded from Egypt, but possibly based on wrong identification, as *ochropterus* is an Indian species (teste Izzard, i. litt.). The insect is unknown to us, in coloration it must be extremely similar to *luridus*.

Pirates Serv.

1 (2) Black, corium with white spots. ..... **chiragra (F.)**
2 (1) Black, or corium dull yellowish brown or ferrugineous (f. *rufipennis* Luc.). ..... **strepitans Ramb.**

Pirates chiragra (F.).

Uncommon, at the Nile and irrigation canals, swamps (VII-XII), or under grasses in moist localities.

Pirates strepitans Ramb.

Common with its f. *rufipennis* Luc. in the Nile valley, at Fayoum and in the Canal Zone. Always on damp places, at canal banks, swamps, the whole year round.

Rhaphidosoma bergevini Popp.

This phasmid-like insect is characteristic to the costal regions, but not tommon, occurring practically all the year, under stones or on the ground between *Gramineae*. One specimen was taken on the Suez Road and another one in the Wadi Garara of the eastern desert.

Vibertia cinerea Horv.

Sinai (V) (coll. Alfieri, and Bodenheimer's list). A specimen from Abu Sueir (Canal Zone), on *Alhagi* (IX). A rare species.

Vachiria natolica Stal.

A very common desertic species, which may be observed the whole year everywhere in the valleys of both deserts, and in Sinai; Canal Zone, Siwa, Dakhla; on and under shrubs and on flowering plants, hunting for other small insects. Larvae were found in July. Varies from pale yellow to dark grey.

Paramphibolus pusillus Reut.

Rather rare and local, with larvae at the base of desert plants (e.g. *Zygophyllum decumbens*) or under stones. Meadi, Helwan, Oasis Siwa, and Sinai (Wadi Gederât) (IV, V, VII, XII).

Amphibolus Klug

1 (2) Blackish brown. Legs clothed with fine, short hairs. Fore angles of pronotum and apex of scutellum blunt. ..... **venator Klug**

2 (1) Testaceous, head and femora darkened. Legs with long, fine, raised hairs. Fore angles of pronotum and apex of scutellum pointed. .... **spec. nov.**

Amphibolus venator Klug.

Uncommon. Usually on the ground near plants, in the desert or its borders; under stones (II-XII). Delta, Canal Zone, Upper Egypt.

Amphibolus spec. nov.

Helouan (IV), on grasses.

This species was identified with *leucopterus* Horv. by Lindberg, but Izzard considers it an unknown species.

Rhinocoris Hahn

Rhinocoris bipustulatus (Fieb.).

Mount Sinai (Bodenheimer's list).

Rhinocoris spp.

Two species of *Rhinocoris*, considered new by Izzard, cannot be described until further material will be available, each species being represented by a unique specimen, only.

Sphedanolestes pulcher Schout.

Rather common on various plants, particularly *Ocimum menthaefolium* Hochst., on the slopes of the Elba mountains (I-III). Ethiopic. Det. W.E. China.

Cosmolestes pictus (Klug).

Recorded from Egypt (Oshanin, 1912).

Coranus Curt.

1 (2) Angles of pronotum pointed. Colour testaceous to dark brown. Connexivum always with dark spots. ..... **angulatus Stal**

2 (1) Angles of pronotum more or less bluntly rounded.

3 (4) Pronotum and corium dull, with felty pubescence. Apex of scutellum not ending in a reflexed spine. ..... **aegyptius (F.)**

4 (3) Pronotum either shining (at least anteriorly), or tip of scutellum spine-like, bent upwards.

5 (6) Wholly yellow species, surface rather smooth and shining, particularly so the calli of the pronotum. Head and fore femora shorter than in *angulatus*. Connexivum without dark markings. ... **arenaceus Walk.**

6 (5) Darker species, connexivum with dark markings, or body nearly black.
7(12) At least apex of scutellum pale, not spiniform and not reflexed.
8(11) Scutellar keel not vertical at apical margin, in lateral aspect.
9(10) Yellowish brown, pronotum with furrow behind calli dark. Head with dark markings. Pronotum shining. Scutellum pale, only basal depression and lateral margins dark; scutellar carina rounded, feebly produced, erect. 8 mm. ..... **blanditus Mill.**
10 (9) Nearly black, tip of scutellum pale. Scutellar keel broadly rounded apically. 8.5 mm. ..... **priesneri Mill.**
11 (8) Larger, greyish brown, tip of scutellum pale. Scutellar spine blunt, vertical apically. Head elongate, sides straight, convergent towards base. ..... **tuberculifer Reut.**
12 (7) Scutellum entirely black. Legs comparatively slender, vertex long, converging behind eyes, with cheeks straight. Connexivum red, with *small* black dots at margins. ..... **niger (Ramb.)**

Coranus aegyptius (F.).

Common all the year, everywhere; in the Delta on dry places, and in the desert. Our southermost record : Fayoum. On and under shrubs and stones, at the lamp. Larvae were found in VII. Predaceous on many insects.

Coranus angulatus Stal.

Common in the deserts, also on dunes, under *Panicum turgidum*, halfa grass, *Citrullus colocynthus*. All over the Delta, in the oases, in Sinai and the Elba mountains. All the year round.

Coranus arenaceus Walker.

Uncommon and more local, especially at the borders of the Libyan desert, Delta Region and Canal Zone. It is also recorded from Sinai (III-IV, VII-XII).

Coranus tuberculifer Reut.

Recorded from Egypt (Oshanin, 1912).

Coranus niger (Ramb.).

Scarce, on the same biotopes as *aegyptius*, sometimes at the lamp, too. Widely distributed (Mex, Damiette, Cairo, Helwan).

Coranus priesneri Mill.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, p. 127).
Gebel Elba (Wadi Aideb, III).

Coranus blanditus Mill.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, pp. 128).
Gebel Elba (Wadi Kansisrob, XII).

Nagusta Stal

1 (2) Elongate, dark, having processes of connexivum pointed. .... **simoni Put.**

2 (1) Less elongate, smaller (8-11.5 mm.), with processes of connexivum rounded. Body usually with red tints, legs greenish. **tuberosa Stal**

Nagusta simoni Put.

Not common. Delta and Giza Province, found with larvae (IX-II) on *Acacia nilotica* and *Acacia farnesiana*. Gebel Elba (Wadi Aideb).

Nagusta tuberosa Stal.

With larvae on *Acacia nilotica*, *Sesbania aegyptiaca* (X-II) over the Delta and in Upper Egypt (Mataana).

12. Family NABIDAE Costa

Key to genera

1 (2) Large (13-15 mm.), black, strongly flattened form. Fore femora very strongly incrassate. ..... **Pachynomus Klug**

2 (1) Not strongly depressed, or smaller forms.

3 (6) Fore femora curved, stout, spinulose.

4 (5) Very small insects, not more than 3 mm., not vividly coloured. .... **Phorticus Stal**

5 (4) Larger, vividly coloured, black and red, with white markings. .... **Prostemma Lap.**

6 (3) Fore femora normal, elongate, not curved and not spinulose. .... **Nabis Latr.**

Pachynomus picipes Klug.

Hitherto only from the Libyan desert, in Menufia and Giza Provinces (IX-XI, II), under stones.

Prostemma septemguttata Stein.

Uncommon, at the base of *Gramineae* (halfa, *Panicum*), borders of deserts. Cairo, north of Giza Pyramids, Helwan, Fayoum (IX-I, V, VII). Det. K. Schmidt. Formerly erroneously under the name of *P. eva* Kirk. in our collections.

Phorticus minutulus Reut.

Between grasses at the borders of swamps, canals (VIII-X), hitherto only at the Pyramids road and the road to Sakkara.

Nabis Latr.

1 (4) Scutellum black, or at least with black median line. Colour never greenish.

2 (3) Cell hook of wing in front of, or at the insertion of, the sector radii. Body more broadly oval (Subg. *Halonabis* Reut.). Yellowish grey-brown species. ..... **sareptanus Dohrn**

3 (2) Cell hook behind insertion of sector radii, upon the connecting vein (Subg. *Reduviolus* Stal). Body much elongate, slender, 9.5-10 mm. Pale greyish yellow ..... **capsiformis Germ.**

4 (1) Scutellum pale, without dark markings. Body of fresh specimens green, corium often with pinkish markings (Subg. *Aspilaspis* Stal). ..... **viridis Brullé**

Nabis (Halonabis) sareptanus Dohrn.

Rabinovitch found this species (VIII) at Mex, presumably under stones, and some specimens at Fayoum under *Tamarix* trees near the lake Karoun (VI). The species was formerly wrongly considered to be identical with *reuterianus* Put. which does certainly not exist in Egypt.

Nabis (Reduviolus) sitiens Walk.

This species is recorded by Royer (*Ann. Soc. Ent. France*, 1914, p. 134) from Sinai. It remained unknown to us.

Nabis (Aspilaspis) viridis Brullé.

Not rare on *Tamarix*. All over the country and in Sinai, all the year. The f. *amoena* Solsky (with pinkish markings) is also Egyptian.

13. Family NAEOGEIDAE Kirk. (Hebridae Fieb.)

Only genus : *Naeogeus* Kirk. (*Hebrus* Curt.)

1 (2) Legs brown to ferrugineous. Hemielytra with fine, whitish pubescence. ..... **pusillus (Fall.)**

2 (1) Legs pale yellow. Hemielytra with golden pubescence. ..... **montanus (Klti.)**

Naeogeus montanus (Klti.).

Sinai (Wadi Ain, Wadi Gederât), on stagnant water. Det. Priesner.

Naeogeus pusillus (Fall.).

Cairo (I), leg. J. Sahlberg. Det. Lindberg.

14. Family MESOVELIIDAE Dgl. Sc.

Only genus : *Mesovelia* Muls.

Mesovelia vittigera Horv.

Fairly common on stagnant and running water, and among detritus of canals, at Alexandria, Meadi, Turrah, Helwan, Pyramids road (I, II, V-XI). The f. macroptera is attracted by the lamp, even far from any pond, in the desert. Larvae IX, X.

15. Family CIMICIDAE Latr.

Only genus in Egypt : *Cimex* L.

Cimex lectularius L.

The common bed bug. All over Egypt.

Cimex pipistrelli Jenyns (?).

In summer 1944, Priesner found at Fayed larval exuviae in the cleft of a rock that served as diurnal hiding place for bats. These skins may be those of *pipistrelli* Jen., though this record needs confirmation after capture of adult specimen..

16. Family POLYCTENIDAE Westw.

Only genus : *Hemischizus* Horv.

Hemischizus intermedius Speiser.

Recorded from Egypt. Parasitic on bats.

17. Family ANTHOCORIDAE A.S.

Key to genera

1(10) Joints 3 and 4 of antennae filiform. Wings sometimes without hamus (Subfam. *Lyctocorinae* Reut.).
2 (5) Wings with hamus.
3 (4) Sides of pronotum at fore angles somewhat curved downward. Metapleurae without carina. Elytra pale. Apex of abdomen often with long setae. ..... **Xylocoris Duf. (Piezostethus Fieb.)**
4 (3) Sides of pronotum distinctly margined in front. Metapleurae between base and apex of orifices with a carina. Elytra densely punctured, general colour brownish. Apex of abdomen without long setae. .... **Lyctocoris Hahn**
5 (2) Wings without hamus.
6 (7) Head scarcely longer than width of frons between eyes. Fore margin of pronotum concave. ..... **cf. Brachysteles Muls.**
7 (6) Head considerably longer than width of frons between eyes
8 (9) Hind margin of pronotum deeply concave. Colour brownish. .... **Cardiastethus Fieb.**
9 (8) Hind margin of pronotum little concave. Colour black. .... **Dufouriellus Kirk.**
10 (1) Joints 3 and 4 of antennae fusiform. Wings always with hamus (Subfam. *Anthocorinae* Reut.).
11(14) Pronotum with distinct ring-like constriction anteriorly.
12(13) Antennal joint 2 simple. ..... **Anthocoris Fall.**

13(12) Antennal joint 2 distinctly enlarged. Surface black, shining, membrane black and white. ..... **Montandoniola Popp.**

14(11) Pronotum not or only indistinctly constricted in front. Orifices of odoriferous glands curved anteriorly, and extended to pleurae in form of a carina.

15(16) Body somewhat widened posteriorly, moderately elongate. Surface more or less punctured. Rostrum longer. .... **Orius Wolff (Triphleps Fieb.)**

16(15) Body much elongate, slender, flattened. Surface impunctate. Basal antenal joint not reaching apex of head. Rostrum very short, extending only just beyond base of head. ..... **Dokkiocoris Mill.**

Anthocoris gallarum-ulmi Deg.

Recorded from Egypt (Oshanin, 1912), but not represented in any of the local collections. Record doubtful.

Montandoniola moraguesi (Put.).

Probably widely distributed, all the year with its early stages in leaf rolls of *Gynaikothrips ficorum* (March.), as an efficient predator of this thrips, on *Ficus nitida*. This insect must be considered a recent accidental introduction, for neither the predator nor the host were observed in this country before 1940. Identification confirmed by W.E. China.

Orius Wolff (Triphleps Fieb.)

1 (2) Pronotum with fine, partly transversely rugose punctuation. Fore angles of pronotum without bristle. ..... **albidipennis (Reut.)**

2 (1) Pronotum shining, posterior part almost without punctures. Fore angles of prothorax with a single raised black bristle.

3 (4) Middle tibiae of male always yellow. Shaded apical part of membrane always sharply separated from hyaline basal portion. Flagellum of aedeagus of male bifid. ..... **laevigatus (Fieb.)**

4 (3) Middle tibiae of both sexes always brown to black. Hyaline basal and shaded apical portion of membrane usually ill-defined, or membrane wholly hyaline or dark. Flagellum of aedeagus of male not bifid. ... . **niger Wolff**

Orius albidipennis (Reut.).

Very common, all over the country, south to Wadi Halfa, in the desert and the cultivated areas. In flowers, on plants infested with *Aphidae* or *Thysanoptera* or other small insects. Adult also feeding on plant tissues of soft parts (e.g. flower petals). Larvae predaceous on various insects, especially plant lice and thrips.

Orius laevigatus (Fieb.).

Common and distributed as the foregoing species, but less numerous in the desert. Habits practically the same.

Orius niger Wolff.

Specimens previously identified with *niger* Wlff., by various authors proved to belong to *laevigatus* (Fieb.). According to E. Wagner (i. litt.), *niger* also occurs in Egypt.

Lyctocoris campestris (F.).

Andres found a specimen at Giza (V), and Alfieri one at Sidi Gaber (IX). We received it occasionally through the Plant Quarantine on imported plants from Turkey.

Xylocoris Duf. (Piezostethus Fieb.)

1 (2) Clavus and corium, at least interiorly, with rows of punctures. Sides of pronotum margined anteriorly (Subgen. *Stictosynechia* Reut.). ... . **cf. maculipennis (Bär.)**

2 (1) Clavus and corium smooth or indistinctly rugose. Sides of pronotum not margined.

3 (4) Abdomen without long setae, at apex. Legs slender, pale yellow. Tibiae sparingly set with fine spines. Macropterous and brachypterous. (Subgen. *Arrosteles* Kirk.). ..... **flavipes (Reut.)**

4 (3) Abdomen with long setae at apex. Legs rather stout, femora often dark. Tibiae stouter, with longer and stouter spines.

5 (6) Larger species, length at least 2.5 mm. .... **galactinus (Fieb.)**

6 (5) Smaller, 2 mm., at the most. Less elongate. ..... **afer (Reut.)**

Xylocoris flavipes (Reut.).

Also known under the name of *Triphleps maderensis* Reut. Macropterous and brachypterous. Common in grain stores, open air stores (shoonas), all over Egypt up to Asswan. Once on branch of *Prunus amygdalus* in channels of *Scolytus*. Often appearing at the lamp. (Illustrated in Willcocks, Survey, etc. II, pl. XVIII, figs. 26 and 27).

Xylocoris galactinus (Fieb.)

In detritus and at the lamp, not common (I, V, VI, IX, XI). Meadi, Pyramids of Giza.

Xylocoris afer (Reut.).

Like the former, but fairly common, particularly at the lamp. Once under *Panicum turgidum*. Nile valley and desert. The whole year.

Brachysteles Fieb.

1 (2) Second antennal joint longer than width of head (inclusive of eyes).

Pale brown. Length 2.5-3 mm. ..... **rufescens (Costa)**

2 (1) Second antennal joint not longer than width of head. Blackish, hemielytra brown to dark brown. Length 2-2.5 mm. **parvicornis (Costa)**

There is no reliable record of any of the two species, from Egypt. A specimen (coll. Alfieri), determined by Bergevin as *Brachysteles rufescens* is identical with *Cardiastethus pseudococci* E. Wagner.

Cardiastethus Fieb.

1 (2) Lateral margin of pronotum straight, strongly converging anteriorly. Embolium strongly widened posteriorly. Legs uniformly pale yellow. Length 1.8-2.1 mm. ..... **pseudococci E. Wagner**

2 (1) Lateral margin of pronotum convex.

3 (4) Femora dark, blackish. ..... **cf. nazarenus Reut.**

4 (3) Legs yellowish to pale fulvous.

5 (6) Length 2.5 mm. ..... **cf. fasciiventris (Garb.)**

6 (5) Length 2 mm. at the most. ..... **nazarenus Reut., var.**

Cardiastethus pseudococci E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, p. 143).

In gardens, on field borders, on shrubs and trees (e.g. on Mango infested with Acarina), uncommon; in the desert occasionally. Alexandria, Meadi, Pyramids of Giza, Assiout (II, VI, XI).

Cardiastethus nazarenus Reut. var.

Recorded from Egypt, but no reliable specimens available except one from Meadi (XII), leg. Priesner, which, according to E. Wagner, may be a variety of this species. It is in any case not identical with the foregoing species.

Dufouriellus ater (Duf.).

Uncommon, at the light. Meadi, Mariout.

Dokkiocoris bicolor Mill.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, p. 130).

Common in the Delta and in Upper Egypt, always on leaves of *Saccharum officinarum* (sugar cane) (VIII, XI), but most likely the whole year.

Years ago, Kiritshenko had already examined this insect and considered a new genus, but he did not describe it. It was only recently dealt with by Miller (l.c.).

18. Family MICROPHYSIDAE Dohrn

Only Egyptian genus : *Microphysa* Westw.

Microphysa basalis Reut.

One male specimen (from Wadi Umm-Mitla, Sinai (III), leg. Rabi-

novitch) belongs, according to W.E. China, most likely to this species, of which the female only is known.

19. Family TERMATOPHYLIDAE Reut.

Key to genera

1 (2) Brownish or yellow-brown, dorsum with scattered golden scales. Sides of pronotum little concave. ..... **Termatophylum Reut.**

2 (1) Black, with short longitudinal lines, composed of slender, silvery scales. Sides of pronotum strongly concave. ..... **Argyrotelaenus Reut.**

Termatophylum insigne Reut.

On trees and bushes (*Acacia, Zizyphus, Ficus,* etc.), orchard plants (e.g. *Solanaceae*), in gardens, on waste places, canal banks, common. Habits of *Orius*. The insect is a predator of thrips (e.g. *Gynaikothrips ficorum* (March.)) and other small insects. All over Egypt. Southermost record : Asswan. All the year. Common at the lamp.

Argyrotelaenus elegans Reut.

Uncommon. Upper Egypt, Nile valley and desert. Northermost record : Meadi. On *Acacia nilotica, Zizyphus* and at the lamp (III, VIII, IX).

20. Family MIRIDAE Dohrn (Capsidae Burm.).

Key to genera

1(28) Arolia of claws large, approximated at base, diverging distally, and sometimes somewhat dilated (Subfam. *Mirinae* Reut.).

2(27) Prothorax with complete, ring-like constriction, at fore margin.

3 (4) Tarsal joint 1 long and mostly *stouter* than the following joints. Genae high. (Tribe *Resthenïini* Reut.). ..... **Capsodes Dahl (Lopus Hhn.)**

4 (3) Tarsal joint 1 seldom long. Genae low (Tribe *Capsini* Reut.).

5(12) Pronotum and hemielytra with conspicuous, sometimes coarse punctuation.

6 (9) Vertex without elevation on posterior margin, or only at sides with a slight marginal carina. Colour never green.

7 (8) Head as long as broad, base of clypeus fused with frons, eyes farther apart from each other. Pronotum anteriorly about as broad as head, broadly truncate. Base of scutellum covered by the pronotum. Dorsal surface dull. Larger form. ..... **Platycapsus Reut.**

8 (7) Head more elongate, eyes more closely approximated. Base of scutellum free. Dorsal surface shining. Smaller forms. ..... **Camptobrochis Fieb.**

9 (6) Vertex with complete marginal line, or body green.

10(11) Dorsum clothed with delicate, metallic setae. ..... **Poeciloscytus Fieb.**

11(10) At least the under side of the body without metallic setae or scales. ..... **Lygus Hahn**

12 (5) Pronotum and hemielytra without conspicuous punctuation, sometimes, however, rugose.

13(26) Hind femora not surpassing apex of abdomen. Antennal joint 1 shorter than pronotum.

14(15) Antennal joints 1 and 2 stout, 2 club-shaped in the female, 3 and 4 short. Apical stricture of pronotum at middle as broad as antennal joint 1. Body short and stout, convex. ..... **Eurystylus Stal**

15(14) Antennae slender, joint 2 not club-shaped. Body more elongate, less convex, larger.

16(19) Vertex without a distinct impressed longitudinal line or furrow, posteriorly.

17(18) Head more or less declivous. Tarsal joint 2 longer than joint 1. ..... **Calocoris Fieb.**

18(17) Head subvertical. Tarsal joint 1 at inferior margin nearly twice as long as joint 2, joint 3 as long as joint 1. ..... **Charitocoris Reut.**

19(16) Vertex with an impressed longitudinal line, posteriorly, or female brachypterous.

20(23) Clypeus not or little protruding, nearly fused with frons.

21(22) Cell of membrane somewhat angulate apically. Dorsum of body with very scarce, fine, metallic pubescence. ..... **Adelphocoris Reut.**

22(21) Cell of membrane bluntly rounded at apex. Surface smooth, without metallic hairs. ..... **Megacoelum Fieb.**

23(20) Clypeus strongly protruding, vertical.

24(25) Rostrum attaining hind coxae. Both sexes macropterous. Sides of pronotum nearly sharp-edged. Body yellowish to brown. **Creontiades Dist.**

25(24) Rostrum scarcely surpassing apex of middle coxae. Sides of pronotum not sharp (male) or blunt (brachypterous female). Body with pink longitudinal lines. ..... **Ischnoscelicoris Reut.**

26(13) Hind femora mostly surpassing apex of abdomen, flattened, narrowed towards apex. Antennal joint 1 mostly at least as long as pronotum, if shorter provided with long hairs. ..... **Phytocoris Fall.**

27 (2) Pronotum without complete anterior ring-like thickening, lateral margin of pronotum attaining fore angles. Tarsal joint 1 long. Very slender forms (Tribe *Mirini* Reut.). ..... **Trigonotylus Fieb.**

28 (1) Arolia not as indicated above, or entirely wanting.

29(44) Pronotum with apical ring. Arolia wanting or closely attached to claws, either wholly or basally united with them (Subfam. *Macrolophinae* Reut.).

30(35) Joint 2 of hind tarsi distinctly longer than joint 3 (Tribe *Macrolophini* Kirk.).

31(32) Head nearly truncate in front. Pronotal calli obsolete. ..... **Habrocoris E. Wagner**

32(31) Head not truncate anteriorly. Pronotal calli distinctly developed.

33(34) Transverse furrow behind pronotal calli not surpassing the latter. Green species. ..... **Engytatus Reut.**

34(33) Transverse furrow behind calli of pronotum reaching lateral margins. ..... **Dicyphus Fieb.**

35(30) Joint 2 of hind tarsi not or little longer than 3. Corium with white spots or bands. (Tribe *Systellonotini* Stich.).

36(41) Antennals 3 and 4 combined much longer than joint 2, the latter about as long as joint 3 or one-third longer.

37(40) Vertex smooth, without marginal elevation.

38(39) Pronotal calli only indicated. Elongate forms, female sometimes ant-like. Head oblique, in lateral aspect, clypeus slightly protruding. Eyes distant from pronotum, with slight concavity within (male). ..... **Systellonotus Fieb.**

39(38) Pronotum with very conspicuous calli which are fused or not. Head vertical. Clypeus strongly protruding, distinctly separated from frons. Eyes touching pronotum, interior margin straight. ..... **Omphalonotus Reut.**

40(37) Vertex with fine, marginal elevation. Base of clypeus distinctly separated from frons. Eyes touching pronotum, interior margins slightly concave or straight. Pronotal calli scarcely or slightly developed. ..... **Laemocoris Reut (9)**

41(36) Antennals 3 and 4 combined little longer than joint 2. Margin of vertex finely elevated.

42(43) Sexes not strikingly dimorphous. Clypeus vertical. Eyes concave within, touching pronotum. ..... **Allodapus Fieb.**

43(42) Sexes strikingly dimorphous. Female brachypterous, with abdomen constricted at base, nearly circular in outline. Clypeus not vertical. Eyes distant from fore margin of pronotum, interior margin convex. ..... **Paramimus E. Wagner**

44(29) Pronotum without ring-like constriction or ring very indistinct, in the latter case arolia free.

45(54) Arolia free, small and slender, sometimes wanting (in this case wing without hamus or body constricted in the middle) or antennals 3 and 4 thicker than 1 and 2 (Subfam. *Heterotominae* Reut.).

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(9) The genus *Tyraquellus* Popp. is said to come very close to *Allodapus* and *Laemocoris*. Unfortunately the description was not accessible.

46(47) Body usually stout. Genae elevated. Tibiae strongly spinulose, hind femora dilated. (*Labopini* Stich.). Not recorded from Egypt.

47(46) Body usually elongate, genae rarely elevated, usually flat. Tibiae seldom dotted with black, hind femora seldom enlarged (Tribe *Heterotomini* Stich.).

48(53) Segments 3 and 4 of rostrum combined longer than segment 2. Small species.

49(50) Body greenish yellow or yellow, with pale orange dots. ..... **Ectagela K. Schm.**

50(49) Body without pale orange dots.

51(52) Vertex not margined. Lorae distinctly separated from genae. ..... **Cyrtorhinus Fieb.**

52(51) Vertex with posterior margin distinctly elevated. Lorae at most indistinctly differentiated. Mostly green species. ..... **Orthotylus Fieb.**

53(48) Segments 3 and 4 of rostrum combined not longer than segment 2. Elongate, pale species. ..... **Platycranus Fieb.**

54(45) Arolia fused with claws, seldom free, in this case wholly adpressed. If arolia short or wanting, wings with hamus (Subfam. *Plagiognathinae* Oshanin).

55(68) Clypeus broad and stout, rarely narrow, in this case xyphus of prosternum (sc. apical process) concave and margined. Body generally dull. (Tribe *Oncotylini* Stich.).

56(57) Cuneus at its interior angle with a circular black dot. Segments of rostrum short, both apical joints strongly dilated towards apex. Arolia very fine, free. Small, green species. ..... **Camptotylus Fieb.**

57(56) Cuneus without conspicuous black dot.

58(59) Arolia broad, strongly dilated. Head nearly vertical, small, not produced. Clypeus narrow, compressed. Eyes large. Rostrum attaining mid coxae. Body dorsally with brown dots. Tibiae with pale spines. ..... **Atomophora Reut.**

59(58) Arolia elongate or lanceolate, seldom vestigial. Body only sometimes with brown dots, but in this case rostrum reaching hind coxae and clypeus broad.

60(67) Rostrum never surpassing middle coxae.

61(62) Body very slender. Antennal joint 1 incrassate, densely pilose. Head and prothorax with longitudinal striae composed of silvery hairs. Legs slender, tibiae pale, with pale spines. ..... **Nasocoris Reut.**

62(61) Body of normal shape. Antennal joint 1 not enlarged. Head and pronotum without silvery striae.

63(66) Basal margin of pronotum slightly concave at middle.

64(65) Tarsal joint 3 longer than 2. Sides of pronotum somewhat concave. Eyes circular, in lateral aspect. (Pronotum green). .. **Conostethus Fieb.**

65(64) Tarsal joint 3 as long as 2. Sides of pronotum not concave. Eyes of male oval, in lateral aspect. (Body with crimson irregular markings). ..... **Stenoparia Fieb.**

66(63) Basal margin of pronotum straight. Arolia not surpassing middle of claws, nearly fused with them. Tibiae set with dark spines. .... **Pastocoris Reut.**

67(60) Rostrum attaining or surpassing hind coxae. Hemielytra densely set with brownish dots. Arolia not surpassing middle of claws. .... **Solenoxyphus Reut.**

68(55) Clypeus slender. Body usually shining. (Tribe *Plagiognathini* Stch.).

69(72) Arolia inconspicuous, not reaching middle of claws, or body not covered with metallic setulae or scales.

70(71) Head very broad, *Geocoris*-like, broader than pronotum, the latter more than twice as broad as long. Colour greenish to yellow, dorsal surface with fine, adpressed, dark and pale hairs. **Eurycranella Reut.**

71(70) Head normal, narrower than prothorax. ..... **Tuponia Reut.**

72(69) Arolia conspicuous, at least attaining middle of claws, or body more or less sparingly clothed with metallic scales. Femora dark, or pale with dark dots, at least proximally with dark spot.

73(74) Head very short and broad. Small (2-3 mm.), pale coloured forms. ..... **Campylomma Reut.**

74(73) Head distinctly longish; if short, body colour dark.

75(76) Base of clypeus on a level with the insertion of the antennae. Body not black. Small forms (1.75-2.4 mm.). ..... **Atomoscelis Reut.**

76(75) Base of clypeus distad of insertion of antennae, *or* body black.

77(78) Antennal joint 2 incrassate, fusiform. **Genus near Atractotomus Fieb.**

78(77) Antennal 2 not incrassate.

79(82) Clypeus not protruding, not visible in lateral aspect.

80(81) Hind tibiae with pale spines, arising from small brown dots. Body elongate. Tarsal joint 3 about as long as 2. ..... **Paramixia Reut.**

81(80) Hind tibiae with dark spines. Elongate-oval. Tarsal joint 2 of hind legs 1.4 times as long as 3. ..... **Psallomimus E. Wagner**

82(79) Clypeus protruding.

83(84) Body and legs shining black, hemielytra and scutellum with a large, common, yellowish white blotch; margins black. Antennals 2-4 fulvous. ..... **Auchenocrepis Fieb.**

84(83) Not of above coloration.

85(86) Eyes smooth or only slightly granulated. Colour often greenish. .... **cf. Plagiognathus Fieb.**

86(85) Eyes coarsely facetted. Body never greenish. Dorsal surface usually with metallic scales. ..... **Psallus Fieb.**

1. Subfamily Mirinae Reut.

Phytocoris Fall.

Note: Our collections contain several speecies of this genus, but the specimens concerned are either in poor condition, thus not reliably to identify, or too few to be dealt with descriptively. From the coastal zones a host of species is to be expected.

Phytocoris desertorum Reut.

In October on *Haloxylon schweinfurthii* in bloom, in the Wadi Umm-Assad, east of Meadi. Det. W.E. China.

Phytocoris scitulus Reut.

Gebel Elba (Wadi Kansisrob), in January. Det. W.E. China.

Ischnoscelicoris rubrinervis (Reut.).

Matrouh (III). Rare, at the lamp, leg. C. Koch.

Creontiades pallidus (Ramb.).

Very common, on various plants (*Zea, Gossypium, Helianthus*, etc.), known as "boll shedder" of cotton (III-XI). All over the country and Sinai, but rare at Gebel Elba. Common at the lamp. *C.p.f. reuteriana* Fairm. has pronotum with brown punctuation, fore and hind margin of it with 2-4 and 8-10 dark dots, respectively. Ground colour of this species varies from greenish over yellow to fulvous.

Megacoelum sordidum Reut.

From Wadi Ibtadi and Wadi Bir Kena (IV, IX), taken from *Tamarix articulata*.

Adelphocoris quadripunctatus (F.).

A specimen of this common European species was found at Matrouh (III).

Calocoris Fieb.

1 (2) Greenish with black pilosity; veins of membrane crimson. .... **instabilis Fieb.**

2 (1) Not greenish with red veins, or, if green, pronotum with two black dots.

3 (4) Yellowish, sides of pronotum, clavus, apex of corium, internal margin of cuneus, crimson. Slender species. Second joint of hind tarsi (at inferior margin) not longer than first. .....**porphyropterus Reut.**

4 (3) No crimson markings, or tarsal joint 2 longer than 1.

5 (6) Pale greyish yellow, without dark markings. Male elongate .... **spec. nov.**

6 (5) Greenish, with black hairs. Pronotum anteriorly with two small black dots. Hemielytra sometimes partly ferrugineous or crimson. .... **norvegicus (Gmel.)**

Calocoris instabilis Fieb.

Amriah (III), coll. Alfieri. Det. Horváth.

Calocoris porphyropterus Reut.

Montazah (III), coll. Alfieri. Det. Priesner.

Calocoris norvegicus (Gmel.).

The typical form and var. *tunetanus* E. Wagner (a dark form with reddish corium). Mariout (II, III). Det. Priesner.

Calocoris spec. nov.

Wadi Abrag, Wadi Abu Gharagid, Wadi Morrah (II-III). Collected by H.C. Efflatoun Bey and H. Priesner. Det. W.E. China.

Charitocoris subglaucus K. Schmidt.

Mersa Halaib and Gebel Elba (II), rather common on *Panicum turgidum.*

Eurystylus bellevoyei (Reut.).

Sometimes in great numbers on low desert plants, especially *Zygophyllum decumbens*, the whole year. Distributed all over the country, also in Sinai and at the coastal zone along the Red Sea to Mersa Halaib. Also attracted by the lamp. In cultivations this species prefers dry localitiees.

Lygus Hahn ([10])

1 (2) Antennal joint 2 as long (male) or shorter (female) than width of head (inclusive of eyes). ..... **Subg. Agnocoris Fieb.**

2 (1) Antennal 2 much longer than width of head.

3 (4) Ground colour green or olive green, not greyish green, often with dark markings. Length exceeding 5 mm., or less, in this case rostrum surpassing hind coxae. ..... **Subg. Apolygus China**

4 (3) Ground colour not green, seldom greyish green, in this case length less than 5 mm., and rostrum reaching but middle coxae.

5 (6) Tibiae, at least exteriorly, with brown spot(s) at base. Spines on tibiae blackish. Larger, 4.6-7.5 mm. ..... **Subg. Exolygus E. Wagner**

6 (5) Tibiae pale, without brown spots at base. Tibial spines mostly pale, at least those on fore tibiae. Smaller, 3.5-5.8 mm. .... **Subg. Orthops Fieb.**

([10]) Subgenera after E. Wagner.

Key to species

1 (2) Antennal joint 2 short, as long (male) or shorter (female) than base of head. ..... **(Agnocoris) rubicundus (Fall.)**

2 (1) Antennal 2 longer than base of head.

3 (4) Rostrum attaining apex of mesosternum. Margin of vertex medianly finer than laterally. Vertex as broad (female) or less broad (male) than one eye. ..... **(Orthops) conspurcatus Reut.**

4 (3) Rostrum attaining or surpassing *hind* coxae.

5 (6) Body brown. Punctuation of pronotum conspicuous. .... **(Exolygus) fuscus Reut.**

6 (5) Body yellowish or green.

7 (8) Pronotum finely rugosely punctured, without dark spots, only apex of cuneus (male) and spots on membrane grey or darker. Usually green. Hind tibiae pale with fulvous spines. Indistinct dark markings on scutellum and corium : f. *prasina* Reut. Pale specimens without brown femoral ring : f. *inops* Horv. ..... **(Apolygus) apicalis Fieb.**

8 (7) Pronotum with coarse punctuation. Usually some dark spots on the pronotum, and the fine lateral margin of the corium dark. Hind tibiae at base with brown spot(s). ..... **(Exolygus) gemellatus (H.S.)**

Lygus (Agnocoris) rubicundus (Fall.).

Recorded from Egypt (Oshanin, 1912), but occurrence unlikely.

Lygus (Orthops) conspurcatus Reut.

Some specimens (V-VII) at our light trap, at Meadi.

Lygus (Apolygus) apicalis Fieb.

Very common, from Matrouh to Alexandria, and over the Delta, Upper Egypt and Sinai. In the cultivated area on wheat, berseem (*Trifolium alexandrinum*); lentils and other crops. Also in the desert. The whole year round.

Lygus (Exolygus) fuscus Reut.

Recorded from Assiout (Reuter 1890).

Lygus (Exolygus) gemellatus (H.S.).

Rather common, the whole year on different crops and grasses. Coastal area, Canal Zone, Delta, Sinai. Fresh specimens in II.

Note : Specimens from Egypt, previously identified with *L. pratensis* L., belong to *gemellatus*.

Camptobrochis Fieb.

1 (4) Scutellum smooth. More elongate species.

2 (3) Pronotum about one-half of basal width, testaceous with dark spots on calli. Rostrum attaining middle coxae. ..... **martini (Put.)**

3 (2) Pronotum only one-sixth shorter than basal width, fuscous; fore margin (inclusive of calli), lateral margin, a median longitudinal line and a fine posterior marginal line pale. Rostrum attaining hind coxae. ..... **sinuaticollis Reut.**

4 (1) Scutellum with scattered, coarse punctuation. Shortly built, smaller form. Varying in colour. ..... **serenus Dgl. Sc.**

Camptobrochis martini (Put.).

Not rare in the north, in the Delta, Giza Province, Fayoum, Suez Canal Zone and Sinai. Particularly on *Tamarix*. Scarce at the lamp. (III-XII).

Camptobrochis sinuaticollis Reut.

On flowers of *Acacia* spp. (I, X). Cairo and Upper Egypt. Rare.

Camptobrochis serenus Dgl. Sc.

Fairly common, also at the light trap. Coastal area, all over the Delta, Kharga. Also in the desert. All the year. There are some colour varieties (cf. E. Wagner, *Boll. Ass. Rom. Ent.*, IV, 1949, pl. I).

C. punctulatus Fall., recorded from this country, is not represented in our collections. All records may safely be referred to *serenus* which was formerly considered a variety of *punctulatus*.

Platycapsus acaciae Reut.

Always on *Acacia nilotica* and occurring most likely on other species of *Acacia*. Coastal plains, Delta, Suez Canal Zone, Upper Egypt, Sinai, Gebel Elba. All the year.

Lopus Hahn

1 (2) Clavus with a white longitudinal vein. Base of antennae and legs with pale pubescence. ..... **lineolatus (Brullé)**

2 (1) Clavus dark. Base of antennae and legs with black hairs. .... **infuscatus (Brullé)**

Lopus lineolatus (Brullé).

On *Asphodelus microcarpus*, in the Marmarica and Mariout (III), common.

Lopus infuscatus (Brullé).

Recorded from Egypt (Oshanin, 1912).

Trigonotylus Fieb. ([11])

1 (2) Clypeus produced conically, surpassing cheeks. Inferior surface of body, as a rule, with crimson longitudinal lines. ..... **cf. pulchellus (Hahn)**

([11]) Key after E. Wagner, i. litt.

2 (1) Clypeus broadly rounded in front, not or hardly surpassing cheeks. Inferior surface of body without red longitudinal lines.

3 (4) Larger, male 4.7-5.3 mm., female 5.3-6.4 mm. Legs longer, hind tibia one-half as long as body (inclusive of hemielytra). Antennal joint 2 : 2.7-3 times as long as width of head. ..... **ruficornis (Geoffr.).**

4 (3) Smaller, male 4-4.3 mm., female 4.6-5.5 mm. Legs shorter, hind tibiae two-fifths the length of the body. Second antennal joint 2.3-2.5 times as long as width of head. ..... **brevipes Jak.**

Trigonotylus brevipes Jak.

Common all the year on *Gramineae* (grasses, cereals as e.g. wheat, maize), on *Trifolium alexandrinum*, *Phaseolus*, *Vicia faba*, and others, all over the country, in the Nile valley south to Asswan and Wadi Halfa. Det. E. Wagner. This species was wrongly identified as *ruficornis* Geoffr. by various authors.

Trigonotylus ruficornis (Geoffr.).

Sinai (Wadi Gederât), in May. Det. E. Wagner.

Subfamily Macrolophinae Reut.

Habrocoris breviceps E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, p. 153).

Cairo, Meadi, Saft (V-VIII), on plants, rare at the lamp.

This is most likely the cotton bug Willcocks described and illustrated (1937, p. 291, pl. IV, figs. 13-17).

Engytatus tenuis (Reut.).

Common in the whole country, sometimes very numerous, particularly on hairy plants, e.g. *Solanum melongena*, *Solanum lycopersicum* and other *Solanaceae*. All the year. Common at the lamp.

Dicyphus Fieb.

Females only of a new species (according to E. Wagner) were collected by Priesner in the Elba mountains (Wadi Aideb, II).

Allodapus longicornis Reut.

Recorded from Egypt. Unknown to us.

Paramimus quinquemaculatus E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, pp. 155-156).

A few specimens, collected by Priesner on the coastal plain near the Red Sea, north of Mersa Halaib (I).

Omphalonotus anomphalus Reut.

Recorded from Egypt (Reuter, 1899).

Laemocoris Reut.

1 (2) Tibiae, tarsi and antennae, except base of joint 1 of the latter, fulvous. Surface of pronotum dull. Female brachypterous. **costai Reut.**

2 (1) Legs and antennae for the major part or wholly dark. Surface of pronotum shining. Female brachypterous.

3 (4) Pronotum of (brachypterous) female, in lateral aspect, concave anteriorly, convex in posterior part. Elytra black, with two yellow blotches. ..... **facetus Horv.**

4 (3) Pronotum of (brachypterous) female straight in front, convex in posterior portion. Elytra near scutellum brownish, the posterior pale blotch of light brown colour. ..... **dispar K. Schmidt**

Laemocoris costai Reut.

This species was formerly identified with *Allodapus longicornis* Reut., in our collections. Males are found, not rare, at the lamp (IV-X), females under *Gramineae* (XII-II). Delta, Upper Egypt.

Note : The differentiation of this insect (described after a female only) from *Allodapus longicornis* seems to be difficult.

Laemocoris facetus Horv.

(cf. K. Schmidt, *Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 392, figs. 16, 17).

Seems to be confined to the coastal area of the north. It was found by Rabinovitch at Mex and Ikingi, in VIII.

Laemocoris dispar K. Schmidt.

(*Bull Soc. Fouad I d'Ent.*, XXIII, 1939, p. 374, figs. 9-15).

Discovered by Rabinovitch and Priesner in October on *Haloxylon schweinfurthii* (in bloom) in the Wadi Umm-Assad, east of Meadi.

Tyraquellus reuteri Popp.

Hayward records this insect (*The Entomologist's Rec.*, 39, 1927) from Asswan. It remained unknown to us.

Systellonotus Fieb.

1 (2) Body black with white markings. ..... **putoni Reut.**

2 (1) Body ferrugineous to dark brown, with pale, whitish and yellowish design. ..... **cf. triguttatus (L.)**

Systellonotus putoni Reut.

At Dabaa, Matrouh, Hamman and Borg-el-Arab (III). This insect runs among black ants (*Tapinoma erraticum* Latr.) of about the same size and shape, on the ground between stones. Collected by Rabinovitch and Priesner.

Systellonotus triguttatus (L.).

Recorded from Egypt (Oshanin, 1912).

Subfamily Heterotominae Reut.

Cyrtorhinus parviceps Reut.

In gardens, moist places on turf, composed of *Gramineae* and *Cyperaceae*. Common at the lamp. Female rare. Meadi, Fayed, Serw (III-V, X).

Ectagela guttata K. Schmidt.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 28, figs. 10-15).

Meadi (V-XI), Kom Ombo (III). Probably from foliage of trees. Not rare at the lamp.

Orthotylus Fieb.

1 (6) At least partly, and always distinctly, *green* coloured species.
2 (3) Elongate, shining green. Dorsum clothed with silvery hairs. Membrane mottled with grey. On *Atriplex*. ..... **fieberi Fr.-Gessn.**
3 (2) Membrane nearly unicolorous, not mottled, *or* small species of 2.5 mm. length.
4 (5) Dorsum dull green, with pale yellow margin of corium. .... **priesneri K. Schm.**
5 (4) Shining green, dorsum sparingly clothed with fine silvery scales. ... . **minutus Jak.**
6 (1) Dull whitish yellow to pale greyish in colour.
7 (8) Elongate. Pubescence not arranged in tufts. Vertex of male 1.5 times, of female twice as broad as the eye. Length 4-4.4 mm. .... **retamae E. Wagn.**
8 (7) Oval. Surface of body clothed with curved whitish hairs which are somewhat arranged in tufts. Length 3.3-4.1 mm. **hirtulus E. Wagner**

Orthotylus fieberi Fr.-Gessn.

In numbers with larvae on *Atriplex* spp., at Borg-el-Arab (V), leg. Priesner.

Orthotylus priesneri K. Schmidt.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 22, fig. 6).

Not rare at the lamp, Cairo and Meadi (V-VIII), and in the oasis Kharga (III). Some specimens of the collection of the Ministry of Agriculture were collected by Adair at Esbeth-el-Nakhl (V, X) and near the Pyramids (IX).

Orthotylus hirtulus E. Wagner.

Meadi, Turrah, Suez Road, uncommon.

Orthotylus retamae E. Wagner.

Suez Road (III), on *Retama raetam* (in bloom), leg. Priesner.

Orthotylus minutus Jak.

Meadi, at the lamp (H. Priesner).

Platycranus putoni Reut.

Always on *Retama raetam* (in bloom) in the eastern desert (Wadi El-Tih, Wadi Umm-Assaad, Suez Road, Wadi Bir Kena, Galala mountains, XII-IV). (From *Orthotylus retamae* easily distinguished by the much elongate, nearly parallel-sided body).

Subfamily Plagiognathinae Osh.

Nasocoris albipennis Lindbg.

Discovered by Priesner in the Wadi Feirân (Sinai), on *Haloxylon schweinfurthii* (V).

Stenoparia putoni Fieb.

Matrouh, at the lamp (III), leg. and det. Priesner.

Conostethus venustus (Fieb.).

Distributed over the northern coast, and certainly not rare, on *Gramineae* but probably other desert plants, too. Alexandria, Mariout, Marmarica (II-III).

Solenoxyphus barbatus E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, p. 147).

Meadi, Wadi Digla (V, VIII), at the lamp (Priesner); Wadi Ashar-el-Bahari (Galala), on *Retama* (V), leg. Alfieri.

Camptotylus yersini (M.R.).

Rather common on *Tamarix*, most likely all over Egypt, for it was found in Cairo (Dokki), Fayed and Kom Ombo (II-VII). Also at the light traps.

Psallomimus bicoloripes E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, pp. 149-150).

Gebel Elba (Wadi Aideb and Wadi Kansisrob, I, II), leg. Priesner.

Psallus Fieb.

1 (2) Dorsum whitish, with small grey-brown dots, and rather densely clothed with silvery pubescence. ..... **adspersus K. Schmidt**

2 (1) Yellowish brown, corium with a common brownish cross-band, apically. Cuneus at apex, and membrane more or less infuscated. .... **deserticola E. Wagner**

Psallus adspersus K. Schmidt.

(*Bull. Soc. Fouad I d'Ent.*, XXIII, 1939, p. 382).

Widely distributed but local in occurrence. Nahia, Helwan, Mahatta Maskhara, Bir Odeibât), appearing at the lamp (XII-V, VIII).

Psallus deserticola E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXV, 1951, p. 159).

Meadi and Wadi Digla, at the lamp; Wadi Umm-Assaad, on *Haloxylon schweinfurthii* (in bloom) (IX, X); leg. Priesner and Rabinovitch.

Gen. spec. nov. ? ear Atractotomus Fieb.

Gebel Elba (Wadi Adaib, I-II, leg. Priesner). Det. W.E. China.

Atomoscelis Reut.

1 (2) Dorsum without black hairs. Tibiae with black spines, emerging from black dots. Length 2.4 mm. ..... **signaticornis Reut.**

2 (1) Surface with scattered black hairs, emerging from small black dots. Tibiae with white spines from black dots. Length 1.75-2 mm. .... **tomentosus Reut.**

Atomoscelis signaticornis Reut.

Heliopolis (I), leg. Sahlberg; Meadi (VI, VIII, IX) at the lamp, leg. Priesner.

Atomoscelis tomentosus Reut.

Heliopolis desert (I), leg. Sahlberg.

Anonychiella fokkeri (Reut.).

Recorded from Egypt (Reuter 1899).

Campylomma Reut.

1 (2) Slender species. Antennae yellowish, joint 1 with two brown pre-apical dots, joint 2 fuscous at apex, 3 and 4 wholly so, or (male) antennae wholly dark. ..... **angustula Reut.**

2 (1) More shortly built species. Antennae paler.

3 (4) Elytra unicolorously pale. Antennal joint 1 with dark basal spot, joint 2 pale. Only tip of clypeus darkened. ....**nicolasi Put. and Reut.**

4 (3) Elytra with embolium and cuneus dark. Antennal 1 with complete pre-apical ring, base of joint 2 dark. Venter shaded. Apical half of clypeus dark. .....**zizyphi Reut.**

Campylomma angustula Reut.

On flowers of *Acacia*. Heliopolis (I), leg. Sahlberg.

Campylomma nicolasi Put and Reut.

The most common *Miridae* species of Egypt. All over the country on cultivated plants (cotton, cereals, etc.) and weeds, desert plants. Common

at the lamp where it was observed feeding on *Chironomidae*. All the year. Cf. Willcocks, Survey, 1922, pp. 34, 66 : 1925, p. 150; 1, 2, 1937, p. 293, pl. VI, figs. 5-7).

Campylomma zizyphi Reut.

Described from Egypt by Reuter (1886); we found it at Meadi, at the lamp.

Paramixia suturalis Reut.

Uncommon. Marg (I), leg. Alfieri, det. Horváth; Wadi Digla (XI), leg. Priesner.

Auchenocrepis minutissima (Ramb.). f. alboscutellata Put.

Always on *Tamarix*, rather common. Sometimes at the lamp. The whole year. Nile valley, Canal Zone. Desert and Oases (Siwa, Baharia).

Tuponia Reut ([12])

1 (8) Hemielytra whitish or ochrous, always with red, ochrous or brown markings, especially along posterior margin of corium.
2 (3) Spines of tibiae white. Cuneus broadly red at middle. Corium with two red cross-bands. ..... **tamaricicola Lindbg.**
3 (2) Spines of tibiae black.
4 (7) Cuneus white, exterior margin sometimes with yellowish brown stripe; veins of membrane whitish.
5 (6) Larger, length 3.5 (male) to 3.75 (female) mm. Hemielytra whitish testaceous, infumations of corium brown, testaceous or fulvous. Corium pale at base. ..... **tamaricis (Perr.)**
6 (5) Smaller, length of male 2.6, of female 3.5 mm. Hemielytra milk-white; markings on corium red or pale red; base of corium with red transverse band. ..... **cf. elegans (Jak.)**
7 (4) Cuneus vividly red or pink, at middle. Veins of membrane red or orange. ..... **lethierryi Reut.**
8 (1) Hemielytra dark green, whitish green or white with green markings,
9(10) Rostrum hardly surpassing fore coxae. ..... **brevirostris Reut.**
10 (9) Rostrum at least attaining middle coxae.
11(18) Tibiae without black dots.
12(17) Dorsum uniformly green, without white design.
13(16) Larger, male 2.6-3.2, female 2.4-3 mm. Vertex of male 1.2-1.7, of female 2.5-2.8 times as broad as eye.
14(15) Eyes very large, vertex of male 1.2, of female 2.4-2.5 times as broad

([12]) Key after E. Wagner, i. litt.

as the eye. Rostrum almost reaching apex of hind coxae. .... **cf. michalki E. Wagn.**

15(14) Eyes smaller, vertex of male 1.7, of female 2.8 times, as broad as the eye. Rostrum reaching apex of middle coxae. **hippophaës (Fieb.)**

16(13) Small, length of male 2-2.4 mm., of female 1.8-2.1 mm. Vertex of male twice, of female 3.2 times, as broad as the eye. Rostrum attaining apex of hind coxae. ..... **unicolor (Scott)**

17(12) Dorsum white with green, or green with white markings. Vertex of male 1.35 times, of female twice, as broad as the eye. .... **guttata E. Wagner**

18(11) Spines of tibiae emerging from black dots.

19(20) Dots of tibiae very small. Vertex of male 2.5-2.75 times, of female three times as broad as the eye. Hemielytra uniformly green. .... **cf. prasina Fieb.**

20(19) Dots of tibiae large and conspicuous. Hemielytra whitish, densely covered, as a rule, with round green spots.

21(22) Head as broad as pronotum at posterior margin. Length of male 3-3.5, of female 2.5-2.6 mm. .... **cf. vitticollis Reut.**

22(21) Head only 0.67-0.8 times as broad as pronotum at hind margin.

23(24) Large and stout, male 2.8, female 2.5 mm. Vertex of male well twice, of female 2.8 times, as broad as the eye. ..... **cf. noualhieri Reut.**

24(23) Smaller, male 1.7-2.3, female 1.7-1.8 mm. Vertex of male 1.8 times, of female 2.5 times, as broad as the eye. Markings as in *guttata* .... **concinna (Reut.)**

Tuponia tamaricis (Perr.).

Widely distributed, on *Tamarix* (III-XII), but less numerous than the following species.

Tuponia lethierryi Reut.

Common on *Tamarix* (III-V, IX-XII), Delta, Upper Egypt, Oases (Siwa, Baharia, Dakhla). Also at the lamp.

Tuponia brevirostris Reut.

Alexandria, Meadi (V-VIII).

Tuponia tamaricicola Lindbg.

(*Bull. Soc. Fouad I d'Ent.*, XXII, 1938, p. 20, fig. 6).

Nile valley, Siwa, Sinai (III-V, X), on *Tamarix*.

Tuponia concinna (Reut.).

Cairo, Marg, Helwan, Meadi; Oasis Kharga; Sinai. On *Tamarix*, a common species, all the year. Det. E. Wagner.

Tuponia guttata E. Wagner.

(*Bull. Soc. Fouad I d'Ent.*, XXXIV, 1950, p. 147, fig. 4).

Alexandria, Cairo, Marg, Meadi (II-VII, X-XI), on *Tamarix* (in bloom), and at the lamp.

(Tuponia conspersa Reut.).

Lindberg gave this name to our *concinna*.

Eurycranella geocoriceps Reut.

From Deshna and Luxor (II); collected by J. Sahlberg; from Tel-el-Kebir (X), coll. Alfieri. Det. Horváth.

21. Family SCHIZOPTERIDAE Reut.

An undescribed, very small representative (0.6-0.7 mm.) of this family was collected by Priesner from grasses on the canal banks of the Sakkara road near the Pyramids of Giza (III, IX). For description, more material will have to be collected.

22. Family HYDROMETRIDAE Billb.

Only genus : *Hydrometra* Latr.

Hydrometra aegyptia Hungfd. and Ev.

Forma macroptera and aptera, the former not rare at the light traps (IV-I). Certainly all over Egypt, all the year, in the Nile valley (Abu Rowash, Marg, Cairo, Meadi-Helwan, Fayoum, Fayed, Kharga).

Specimens, previously identified as *H. stagnorum* L. or *H. gracilenta* Horv. belong to the above species.

23. Family GERRIDIDAE Leach

Key to genera

1 (2) Head, pronotum and elytra shining. Body elongate. **Limnogonus Stal**
2 (1) Body surface dull, clothed with extremely fine, adpressed, silky pubescence.
3 (4) Larger forms with very long, fine legs. Abdomen elongate, as long as thorax or little shorter. ..... **Gerris F.**
4 (3) Body short, abdomen much shorter than thorax, shortly conical.
5 (6) Hind femora not longer than body. Head longer than broad between eyes, its hind margin straight. ..... **Naboandelus Dist.**
6 (5) Hind femora longer than body. Head between eyes broader than long, hind margin convex. ..... **Halobates Eschsch.**

Gerris brevirostris Bergr.

Gederât in Sinai (V), in coll. Alfieri.

This species belongs to the group having middle of thorax fulvous.

Limnogonus leptocerus Reut. (aegyptiacus Put.).

All over Egypt (incl. Sinai), rather common, all the year. Macropterous

and brachypterous forms about equally frequent, in both sexes. Larvae found IX-I. On stagnant and running water.

Halobates hayanus B.Wh.

Only found by H.C. Efflatoun in January at the Red Sea shore of Mersa Halaib.

Naboandelus bergevini Bergr.

Only local, the macropterous form rare at the lamp (Cairo, Meadi, Fayoum, Helwan), VI, VIII, X-III; larvae XII.

24. Family VELIIDAE Dohrn

Key to genera

1 (2) Terminal joint of mid tarsi split, with a tuft of plumose bristles. Larger form, at least 3.5 mm., blackish. .... **Rhagovelia Mayr**

2 (1) Legs short, tarsi without a tuft of bristles. Smaller forms, 1.5-2.8 mm. ..... **Microvelia Westw.**

Rhagovelia nigricans (Burm.).

Port-Said, Zagazig (V-VII), only locally common; larvae VII.

Microvelia Westw.

(After Hoberlandt 1951, i. litt.)

1 (2) Antennae stout, joint 1 long, extending for more than two-thirds of its length beyond apex of head. Pronotum of apterous from long, covering meso- and metanotum for the major part; meso- and metanotum visible as small lateral lobes. Male parameres symmetrically developed; the comb of pegs on male fore tibia occupying 1.7-1.8 of its length. ..... **cf. Microvelia (Pseudovelia) major major Poisson**

2 (1) Antennae slender, joint 1 short, extending beyond apex of head for less than one-half of its length. ..... **Microvelia s.str.**

3 (6) Pronotum of apterous form short, mesonotum uncovered, visible as transverse band, metanotum visible as triangular lobe or both, mesonotum and metanotum visible as lateral triangular lobes. Male parameres symmetrically developed. Body rather broad.

4 (5) Mesonotum visible as a transversal stripe, metanotum as lateral triangular lobes. Antennal joint 4 twice (or a little more) as long as joint 1. ..... **cf. reticulata (Burm.)**

5 (4) Meso-and metanotum visible as lateral triangular lobes. Fourth antennal joint 1.8 times as long as joint 1. ..... **waelbroecki Kirk.**

6 (3) Pronotum of apterous form long, covering mesonotum, and only the metanotum being visible as lateral triangular lobes. Male parameres

asymmetrically developed : right sickle-shaped, left reduced. Body relatively narrow.

7(10) Fourth antennal joint 1.8-2.5 times as long as joint 1.

8 (9) Fourth antennal joint 2-2.15 times as long as first joint and distinctly longer than second and third joints combined. Legs of usual length. ..... **cf. gracillima Reut.**

9 (8) Fourth antennal joint 1.8 times as long as first and distinctly shorter than second and third joints combined. Legs usually long.... ..... **priesneri Hoberl.**

10 (7) Fourth antennal joint 1.4-1.5 times as long as first joint.

11(12) Abdomen in the middle of its length nearly as broad as pronotum, 1.5 times as long as wide. Connexivum broad, flat, exterior margin rounded. Pronotum unicolorous. .... **pygmaea (Dufour)**

12(11) Abdomen narrower than pronotum, distinctly narrowed towards apex, twice as long as wide. Connexivum narrow, sub-erected, exterior margin straight. Posterior margin of pronotum pale. **cf. hozari Hoberl.**

Microvelia waelbroecki Kirk.

Rather rare, at the lamp. Meadi (VI-X), leg. Priesner; f. brachyptera collected by Patrizi in Fayoum (VI). Det. Hoberlandt.

Hitherto known from tropical Africa.

Microvelia pygmaea (Duf.) (nilicola Costa).

Common on stagnant and running waters and at the lamp (V-II). Delta, Giza Province, Fayoum, Fayed.

Microvelia priesneri Hoberlandt.

Alexandria (IX), in garden pond (leg. Priesner).

25. Family LEPTOPODIDAE Costa

Key to genera

1 (2) Much elongate, greyish, setose. ..... **Valleriola Dist.**

2 (1) Rhomboidal forms. Body spinulose.

3 (6) Antennal joint 3 considerably longer than 2.

4 (5) Antennal joint 2 distinctly more than twice as long as joint 1. Segment 2 of rostrum unarmed. Eyes not spinulose. (In Algeria : *marmoratus* (Goeze) and *hispanus* (Ramb.)). ..... **cf. Leptopus Latr.**

5 (4) Antennal joints 1 and 2 subequal. Segments 1 and 2 of rostrum set with spines. (Eyes spinulose in subgen. *Patapius* s.str.). .... **Patapius Horv.**

6 (3) Antennal joint 3 somewhat shorter than 2. ..... **cf. Erianotus Fieb.**

Patapius Horv.

1 (2) Elytra with greyish markings and an ill-defined transverse band, posteriorly. Membrane grey, with brownish veins. ... **spinosus (Rossi)**
2 (1) Elytra with a black, sharply defined, deltoid, transverse band. Membrane and veins pale. ..... **spec.**

Patapius spinosus (Rossi).

Turrah, Massara, Talbiah, Pyramids of Giza (IX-I), under stones and detritus, uncommon.

Patapius sentus Drake and Hoberl. (ined.).

Egypt (Hoberlandt in litt.).

Patapius spec.

Wadi Digla (VIII, X), under stones, leg. Rabinovitch and Priesner.

Valleriola assouanensis Costa.

Under and on stones and rocks, at the Nile. Cairo-Barrage, Assouan, El-Derr (IV, IX, XI).

26. Family ACANTHIIDAE Leach (Saldidae Costa).

Key to genera

1 (2) Membrane well developed. ..... **Saldula V.D.**
2 (1) Membrane wanting. Body very small (1.5 mm.), beetle-like. ..... **Dolifusella China**

Saldula V.D.

1 (2) Small species, length 2.3-3.3 mm. Apex of clavus usually with small yellow dot. Corium black, margins yellow, the latter interrupted by a dark cross-band. Lateral margin of pronotum straight. Fore tibiae mostly yellow. ..... **ornatula (Reut.)**
2 (1) Larger, length 3.3-4 mm.
3 (4) Fore tibiae dark at base and apex, without dark line at middle. Hemielytra black with pale markings or largely pale, base, interior margin and three spots on exterior margin of corium dark: f. *imitator* Reut.; or spots of hemielytra enlarged: f. *inversa* Stich. ..... **mutabilis (Reut.)**
4 (3) Fore tibiae broadly dark, pale at apex; or at least with dark stria from base to beyond middle.
5 (6) Lateral margin of pronotum slightly convex. Margin of elytra pale, dark at base, with 2-3 small dark spots, or entirely pale yellow. Corium with oily shine. Length 3.3-4 mm. Varieties: A white

spot on tip of clavus, a pale cross-band attaining clavus suture and being curved distad towards tip of clavus: f. *confluens* Reut.; hemielytra whitish to yellowish, clavus (a distal spot yellow), base and exterior distal angle of corium or also interior margin and two marginal spots, black: f. *dimidiata* Curt. ..... **pallipes (F.)**

6 (5) Lateral margin of pronotum nearly straight. Elytra, except at base, wholly pale, or with only one lateral dark spot.

7 (8) Elytra, excepting base, wholy pale yellow. ..... **pallipennis (Reut.)**

8 (7) Elytra, excepting base, pale, with a longitudinal dark spot attaining margin, and with tip of corium black. Apex of clavus yellow. Elytra dull, without oily shine. ..... **arenicola (Schltz.) f. simulator Reut.**

Note: All material of this genus available was reviewed by Dr. L. Hoberlandt (Prague).

Saldula ornatula (Reut.).

Mariout, Damiette, Meadi, Turrah, Helwan, Luxor. The whole year. Rare at the lamp.

Saldula mutabilis (Reut.).

Cairo (I), at the banks of the Nile. Not represented in Egyptian collections.

Saldula pallipes (F.).

All specimens paler than the European ones we could examine; the Egyptian specimens belong to f. *confluens* Reut. and (chiefly) to f. *dimidiata* Curt. Everywhere in the Delta, the northern coast and the oases, South to Assuan. The whole year, at canal banks, ponds, swamps.

Saldula pallidipennis (Reut.).

Hoberlandt refers two specimens from Egypt (coll. Min. Agric., without label) to this species, but he considers the species doubtful.

Saldula arenicola (Schltz.) f. simulator Reut.

One specimen from Wadi Gederât, Sinai (V), coll. Alfieri.

Dolfusella minutissima China.

Island of Seafir at the southern extremity of the Sinai peninsula, in a rock crevice at high tide level (IV).

27. Family OCHTERIDAE Kirk. (Pelogonidae Leach)

Only genus : *Ochterus* Latr. (*Pelogonus* Latr.)

Ochterus marginatus Latr.

One specimen from Alexandria (coll. Alfieri).

28. Family NAUCORIDAE Fall.

Key to genera

1 (2) Rostrum long, surpassing middle coxae. ..... **Aphelochirus Westw.**
2 (1) Rostrum short, attaining fore coxae.
3 (4) Small form, about (6 mm. long Pronotum not so broad as the elytra. Dorsum flat. ..... **Heleocoris Stal**
4 (3) Larger, exceeding 10 mm. Fore femora strongly incrassate. Dorsum convex. ..... **Macrocoris Sign.**

Aphelochirus aestivalis F.

Recorded as doubtful from Egypt (Oshanin, 1912).

Heleocoris minusculus Walk.

According to Bodenheimer occurring throughout the Sinai mountains. A. Schatzmayr collected it in the Wadi Isla.

Macrocoris flavicollis Sign.

Dr. Lotte took one specimen from Lake Menzala (II). Det. Priesner.

29. Family BELOSTOMATIDAE Leach

Key to genera

1 (6) Very large insects, exceeding 40 mm. in length.
2 (3) Body depressed, broadly oval, pointed in front and posteriorly. Fore femora slender. Fore tarsi with two claws. ..... **Limnogeton Mayr**
3 (2) Body elongate and more convex, shining. Fore femora enlarged, compressed.
4 (5) Fore tarsi with one claw. Scutellum somewhat broader than long. Anterior angles of prothorax blunt. Head less broad, width not exceeding 10 mm., eyes not surpassing fore angles of pronotum. .... **Lethocerus Mayr (Belostoma Latr.)**
5 (4) Fore tarsi with two claws. Scutellum forming an exactly equilateral triangle. Prothorax rounded anteriorly. Head broader, eyes surpassing fore margin of pronotum. Frons with median longitudinal carina. ... . **Hydrocyrius Spin.**
6 (1) Smaller insects, not exceeding 25 mm. in length. Body flattened dorsally. ..... **Sphaerodema Lap. (Diplonychus Lap.)**

Lethocerus niloticus Stal (cordofanus Mayr).

Not rare, in the Nile and its canals; egg-mass normally deposited around grass above the water. Appears at the lamp. The whole year, particularly towards autumn. All over the country, in the Nile valley. Larvae were seen in IX.

Hydrocyrius columbiae Spin.

A specimen collected by Alfieri at Turrah (IX).

Limnogeton fieberi Mayr.

Here and there in the swimming pools and at the lamps, but not common (VI-X). Nile valley, Fayed. Eggs are laid on top of the male, as in *Sphaerodema*.

Sphaerodema urinator (Duf.).

Common in water pools and canals, all the year, in the Nile valley and in Sinai. Larvae (IX-XII).

Sphaerodema nepoides (F.) is considered synonymous with *S. urinator*, by various authors, and the name *nepoides* (F.) would have priority. In any case, we only know one species from Egypt, agreeing with the re-description given by Jaczewski (1936).

30. Family NEPIDAE Leach

Key to genera

1 (2) Elliptical, flattened, grey. Head much narrower than pronotum at fore margin. Fore femora incrassate. ..... **Laccotrephes Stal**

2 (1) Very slender forms. Head broader than pronotum at fore margin. Fore femora not enlarged. ..... **Ranatra F.**

Laccotrephes fabricii Stal.

Sinai. Bir Abrag (Eastern Desert). Elba mountains. In semi-stagnant waters, all the year, but not in great numbers. Larvae observed VIII and I.

Ranatra F.

1 (2) Legs with pale grey markings. Hind femora somewhat surpassing apex of abdomen. Respiratory tube little shorter than thorax and abdomen combined. ..... **longipes Stal**

2 (1) Legs testaceous. Hind femora not reaching apex of abdomen. Respiratory tube distinctly shorter than thorax and abdomen combined. ..... **vicina Sign.**

Ranatra vicina Sign.

Locally common in stagnant water and in irrigation canals. All the year, in the Nile valley. Larvae seen in IX and X.

Ranatra longipes Stal.

Recorded from Egypt (Oshanin, 1912).

31. Family NOTONECTIDAE Leach

Key to genera

1 (2) Small, length at most 4 mm. Body strongly covex, short, conical.

Hemielytra without a membrane. ..... **Plea Leach**

2 (1) Larger, elongate, conical forms.

3 (4) Hemielytra transparent, smooth and shining. Antennal 4 longer than 3. ..... **Anisops Spin.**

4 (3) Hemielytra opaque, pubescent. Antennal 4 shorter than 3. ..... **Notonecta L.**

Plea Leach

1 (2) Prothorax densely punctured. Length 2.5-3 mm. ..... **leachi McGreg. and Kirk.**

2 (1) Prothorax less densely, but more coarsely punctured. Length about 1.5 mm. ..... **letourneuxi Sign.**

Plea leachi McGreg. and Kirk. (minutissima Füssl.).

Collected by Patrizi in the Wadi Natroun. Det. Priesner.

Plea (Paraplea Es. and Ch.) letourneuxi Sign.

Common, but local, in stagnant water and at the lamp; also in the desert (VIII-XI).

Anisops Spin.

1 (2) Head with fore margin straight, between eyes. Darker and broader than *sardea*, scutellum, for the major part, dark. ..... **varia Fieb.**

2 (1) Head convex between eyes (female) or pointed (male). Colour whitish to pinkish or orange. ..... **sardea H.S.**

Anisops varia Fieb.

This species seems to be less evenly distributed than the following. Cairo and Sinai. In pools of water and at the lamp.

Anisops sardea H.S. (producta Fieb.).

Common all the year, all over Egypt (Nile valley, Kharga, Sinai).

May appear at the lamp in great numbers (swarms) in both sexes, even in the desert. Larvae IX-XII, but more common in IX and X.

Notonecta L.

1(10) Large species, length 13-16 mm.

2 (3) Scutellum wholly unicolorous, yellow or white. ... **cf. pallidula Poiss.**

3 (2) Scutellum black.

4 (5) Fore angles of pronotum produced anteriorly, pointed, surrounding base of head. Elytra greenish yellow or (f. *mediterranea* Hutch.) profusely dotted with brown. ..... **viridis Delc.**

5 (4) Fore angles of pronotum slightly produced or blunt.

6 (7) Metanotum and dorsum of abdomen yellow or fulvous, except tergites II-IV(V). Elytra intensively spotted with brown or black. .... **maculata F.**

7 (6) Metanotum and dorsum of abdomen black or blackish brown.

8 (9) Elytra red or brownish, more or less spotted, with a pale longitudinal band on the clavus or another one on the corium (f. *hybrida* Poiss.), or with some faint black lines at margins and some dots on disk (f. *rufescens* Poiss.). ..... **glauca L.**

9 (8) Elytra velvet-black, sometimes shining, with one or two yellow bands at base, the latter usually replaced by yellow spots. .... **obliqua Gall. f. meridionalis Poiss.**

10 (1) Smaller species, length 8.5-9 mm. Body more shortly built. Colour pale greyish (to greenish) yellow. ..... **spec.**

Notonecta viridis Delc.

We saw specimens from Edfu (ex coll. Mader).

Notonecta maculata F.

Recorded from Egypt (Jaczewski 1936).

Notonecta glauca L.

Recorded from Egypt (Jaczewski 1936).

Notonecta spec.

Oasis Kharga and Dakhla (coll. Min. Agric.).

32. Family CORIXIDAE Leach

Key to genera

1 (4) Scutellum not visible, covered by the pronotal process. Antennae 4-segmented. Length of body at least 4 mm. (Subfam. *Corixinae* Jacz.).

2 (3) Pronotum smooth, with more than 12 yellow transverse lines. Width of body exceeding 3.5 mm. ..... **Corixa Geoffr.**

3 (2) Pronotum very densely and finely rugose, with at most 12 yellow transverse lines. Width of body not exceeding 3 mm. ..... **Sigara F.**

4 (1) Scutellum visible. Antennae 3-segmented. Very small forms. (Subfam. *Micronectinae* Jacz.). ..... **Micronecta Kirk.**

Corixa Geoffr.

1 (2) Blackish brown, pronotum wih 12-14 pale, transverse lines. Pala of male somewhat widened towards apex where it is nearly truncate, having fore margin rounded. ..... **affinis Leach**

2 (1) Yellowish white, pronotum with 9-11 dark transverse lines. Pala of

male crescent-shaped. Middle of sternum black, venter whitish. ... . **platycnemis (Fieb.)**

Corixa affinis Leach.

Around Cairo (Abu Zabal, Turrah, Talbia, Helwan, Memphis (XII-VIII)).

Corixa platycnemis (Fieb.).

Recorded from Egypt, but not represented in Egyptian collections.

Sigara F.

(In all Egyptian species known to us, the corium is not rastrate, but more or less finely punctured and pubescent).

1 (8) Frontal fossa of male not divided by a faint transverse carina.

2 (7) Yellow striae of pronotum broader than black ones. Fossa of frons of male ending in a nearly pointed arch. Punctuation of corium extremely fine. Length 5-6 mm.

3 (6) Pronotum with 7-9 black transverse lines.

4 (5) Pala of male with a continuous row of comb-teeth of about equal size. Strigillum small, roundish, at least with three rows of teeth. Pronotum with 8-9 fairly regular dark lines. .... **hieroglyphica (Duf.)**

5 (4) Pala with a row of teeth that does not surpass middle of it; about 10 basal teeth are larger than 14-15 distal ones. Pronotum with 7-8 black lines, the basal ones mostly interrupted (Algeria). .... **cf. vermiculata (Put.)**

6 (3) Pronotum with 10-11 black transverse lines. Strigillum reduced to a slender, tongue-shaped production. (Algeria). ..... **cf. scripta (Ramb.)**

7 (2) Frontal fossa truncate at apex. Pronotum with 6 yellow striae which are narrower than the black ones. Punctuation of corium more conspicous. Pala rather blunt apically, with one regular row of teeth. Strigillum with several rows of teeth. ..... **hedenborgi Lundbl.**

8 (1) Frontal fossa of male divided into two parts by a faint transverse ridge.

9(10) Frontal fossa of male not very deep, its transverse keel situated on a level with the hind margin of the eyes. Pala short, strongly dilated in basal half, pointed at apex, exterior margin somewhat concave in distal half. Strigillum with two rows of teeth (in *lugubris* Fieb. from Algeria with one row). Length 6-6.5 mm. ..... **mayri Fieb.**

10 (9) Fronal fossa and transverse carina more conspicuous, the latter situated more distad. Pala long and slender, with parallel edges. Strigillum with three rows of teeth. Length 5 mm. ..... **selecta Fieb.**

Sigara hieroglyphica (Duf.).

Common all over Egypt and Sinai, nearly all the year, often appearing at the lamp (III-XII).

Sigara mayri Fieb.

Meadi, Wadi Digla, Turrah, Helwan. In ponds and at the lamp, the whole year, much less numerous than the foregoing species.

Sigara selecta Fieb.

Turrah (I-III, XI).

Sigara hedenborgi Lundbl.

Marg, Turrah, Helwan (IX-III).

Micronecta Kirk.

1 (2) Length 2.25-2.5 mm. Hemielytra sparingly and very indistinctly punctured. Free lobe of left part of VIIIth abdominal tergite narrow, not concave at apical margin. ..... **isis Horv. (horvathi Lindbg.)**

2 (1) Length at least 3.2 mm. Hemielytra, though very finely, more densely punctured. Free lobe of left part of VIIIth abdominal segment broad, concave at apical margin.

3 (4) Proportion of middle claw to tarsus = 6 : 7. Left side paramere of male somewhat angularly curved in apical part. Apex of membrane more rounded. Length 3.25-3.75 mm. ..... **plicata (Costa)**

4 (3) Proportion of middle claw to tarsus = 3 : 4. Left side paramere only slightly, not angularly curved. Apex of membrane obtuse-angled. Pronotum more strongly transverse. .... **scutellaris (Stal) (including decipiens Horv.)**

Note : *Micronecta horvathi* Ldbg. and *M. decipiens* Horv. are not considered valid species.

Micronecta plicata (Costa).

In ponds and at the lamp, common all the year. All over Egypt.

Micronecta scutellaris (Stal).

Meadi, Turrah, Giza (I, V, VIII), comparatively rare.

Micronecta isis Horv.

Cairo, Meadi (V-VIII), like *plicata*, but decidedly less common.

ADDENDUM

To page 24 : *Dolycoris varicornis* Jak. occurs in Sinai (coll. Fouad I University). This species may be recognized by the black antennae and the darkly striate membrane.

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On the effect of Carbon Tetrachloride upon etherized *Drosophila virilis*

[Diptera-Drosophilidae]

(with 3 Tables)

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CONTENTS

I. Introduction. — II. Method and material. — III. Recovery time of flies subjected to carbon tetrachloride. — IV. Effect of ether upon the flies. — V. Carbon tetrachloride symptoms upon etherized flies. — VI. Conclusion. — VII. Bibliography.

I. INTRODUCTION

During the early experiments that were carried to study the effect of higher percentages of carbon dioxide and carbon tetrachloride upon the wing-beat frequency of *Drosophila virilis* the author used various methods of quieting the flies before transferring them to the fumigation chamber; among these he tried the method of subjecting the flies to ether in order to make them convenient to handle. It was noticed that those flies which were subjected to the effect of ether gave remarkably contradicting results as far as the recovery time of ether is concerned. This fact alone made it necessary to investigate the effect of the fumigant at hand upon the etherized and over-etherized flies.

It is well known that ether is used in many fields as an anesthetic Many workers apply the etherization method in their experiments on living specimens for its practical advantages.

Various authors pointed out the marked effects the anesthetics have upon the carbon dioxide output and the oxygen intake of organisms. In order to study the action of these chemicals upon organisms, Bodine (1923) gave

particular attention to the initial and recovery stages of anesthesia. It has been shown, for example, that ether, in the initial stages of its action, produces in the case of plants and some animals an initial lowering of the rate of carbon dioxide output followed by a rapid increase, and this in turn is succeeded by a fall.

Bodine concluded that marked changes in the rate of carbon dioxide output in grasshoppers are produced by ether and the order in which various parts of an animal recover from ether is — first, the respiratory movements, then movements usually controlled or inhibited by the brain and finally, the brain itself.

After consulting the current literature the author could not find any work which was done on the effect of a fumigant such as carbon tetrachloride upon insects that have been subjected previously to the effect of ether.

II. METHOD AND MATERIAL

The method which has been used in this study was simply to subject flies selected at random from a rearing stock to the effect of varying concentrations of the fumigant. In order to get variations in the concentration of the fumigant, air is allowed to bubble through columns of liquid carbon tetrachloride and then by the aid of calibrated flowmeters the saturated air delivered to the mixing bottle could be measured in liters per minute. By increasing or decreasing the amount of air saturated with the fumigant in comparison to the total amount of pure air allowed to go into the fumigation chamber one can get considerable variations in the total concentration of carbon tetrachloride given to the insects.

Knowing the vapor pressure of the substance used at a given temperature, its concentration in grams per litre of air could be easily calculated using the equation :

$$\text{Total concentration in grams per litre} \quad \frac{\text{vapor pressure}}{760} \times \frac{273}{273 + t} \times \frac{1}{22.4} \times \text{Mol. wt.}$$

The gases were allowed to mix in a spacious jar before being introduced to the fumigation chamber which is a wide glass tubing 3 cms. in diameter and 20 cms. in length with an inlet and an outlet for the gases.

III. RECOVERY TIME OF FLIES SUBJECTED TO CARBON TETRACHLORIDE

Several tests were conducted to study the correlation between the dosage of fumigant used and the recovery time for the insects. The standard experimental procedure was briefly as follows :

Groups of 30 flies were confined in the fumigation chamber. These flies taken from the stock could be from newly emerged to several days old.

After exposing the insects to the known concentrations of the fumigant for a fixed period of time and recording their stupefaction period, they were removed to a clean aerated place where they could be put under continuous careful observation to record their recovery time. The recovery time of 50 per cent of the group was always taken as representative of the group under these test conditions.

The results of these experiments show that the higher the concentration of the fumigant, the longer the recovery time for the insect until one reaches the lethal dosage. Also, the more the insect is exposed to the effect of the toxic action of carbon tetrachloride, the longer will be its recovery period (Table I).

TABLE I

Recovery time of flies subjected to the effect of carbon tetrachloride

CONCENTRATION OF CARBON TETRACHLORIDE IN GRAMS PER LITRE	STUPEFACTION PERIOD IN MINUTES	PERIOD OF EXPOSURE IN MINUTES	AVERAGE RECOVERY TIME FOR 50 % IN MINUTES
0.07	11	12	10
0.07	11	20	14
0.12	9	10	12
0.12	9	15	16
0.23	7	8	18
0.23	7	10	22
0.48	4	5	25
0.48	4	7	30

Taking as an example for the effect of carbon tetrachloride a test where the flies were subjected to a concentration of carbon tetrachloride of 0.23 gram per litre, the average recovery time here reached a period of about 20 minutes.

IV. EFFECT OF ETHER UPON THE FLIES

It has been found that normal flies etherized only until stupefaction were, with the exception of a few of them, completely relaxed. It removed at that time from the ether, their wings would stay in the normal resting position and their legs would be bent in the manner assumed by flies at rest. Such flies subjected to a slight dosage of ether would recover within an average of 20 minutes after their removal from the anesthetic and then they seemingly behave normal afterwards. Yet flies left for a longer time in the etherizer behaved quite different. Their wings would be folded backwards and upwards and their legs were stretched out and held stiffly away from the body. Usually flies thus over-etherized did not recover from the narcosis and died in that position.

In contrast with this, the flies stupefied by carbon tetrachloride fumes show quite a different way of wing position. The majority were stupefied with their wings held upwards or downwards and not in any way resembling the resting form. The legs were also almost always stretched out completely with apparent vigorous telescopic movements of the abdominal segments.

TABLE II

Recovery time of etherized flies

CONCENTRATION OF ETHER IN GRAMS PER LITRE	STUPEFACTION PERIOD IN MINUTES AND SECONDS	PERIOD OF EXPOSURE IN MINUTES	AVERAGE RECOVERY TIME FOR 50 % IN MINUTES
0.21	1.10	2	12
0.21	1.15	4	20
0.56	0.50	2	18
0.56	0.55	4	29
0.84	0.40	2	25
0.84	0.45	4	38

The standard concentration of ether used for these tests was 0.21 gram per litre and the time of exposure was four minutes. Here, also, it was quite true that by increasing the dosage of ether either by increasing its concentration or by extending the exposure period, prolongation of the recovery time takes place until the lethal dosage or overanesthesia is reached and no recovery but death of the flies follows (Table II).

V. CARBON TETRACHLORIDE SYMPTOMS UPON ETHERIZED FLIES

In order to examine the effect of toxic carbon tetrachloride upon the slightly etherized flies, i.e., those subjected to ether concentration of 0.21

TABLE III

Recovery time of slightly etherized flies (ether concentration of 0.21 gram per litre and 4 minutes) after carbon tetrachloride fumigation

CONCENTRATION OF CARBON TETRACHLORIDE IN GRAMS PER LITRE	PERIOD OF EXPOSURE IN MINUTES	AVERAGE RECOVERY TIME FOR 50 % IN MINUTES
0.07	3	5
0.07	6	3
0.12	3	7
0.12	6	4
0.23	3	8
0.23	6	6
0.48	3	12
0.48	6	18

gram per litre for four minutes, several tests were run subjecting groups of these etherized flies to a known dosage of carbon tetrachloride. These insects show peculiarly unique activity while recovering from the effect of both anesthetics. They start after a comparatively short time of stupefaction, gliding around, dragging their seemingly paralysed legs, by the vibrations of their wings; the first parts recorded showing any sign of recovery were the wings, while in the case of carbon-tetrachloride stupefaction alone, the insects show their first signs of recovery through the activity and movements of their legs, and the flight activity of the wings is the last to be demonstrated.

Several tests made clearly show that slightly etherized flies, when subjected to a dosage of carbon tetrachloride enough to cause stupefaction, would recover in almost less than half the time required for the flies to recover from the effect of carbon tetrachloride alone or even ether alone (Table III).

By reversing the procedure of the above experiments and subjecting the flies first to carbon tetrachloride until stupefaction and then, before they gained recovery, to the anesthesia of ether, the recovery time in these cases was greatly increased. Likewise, when a mixture of the two anesthetics is used upon the flies, it has been found that these flies require a longer period for recovery. So it was only in the case of introducing carbon tetrachloride following ether, that the flies did recover much more sooner than in the case of using either one of the anesthetics alone.

VI. CONCLUSIONS

1. Stupefaction of *Drosophila virilis* by ether is different from that by carbon tetrachloride, at least as far as the wing positions of the flies are concerned in both cases.

2. Recovery time for the insect concerned increases with the increase of the dosage of either ether or carbon tetrachloride given to the insect.

3. Adult etherized flies recover from a sublethal dosage of carbon tetrachloride in a shorter time than those flies which are subjected only either to a dosage of ether or to a dosage of carbon tetrachloride.

4. If the flies are subjected to a mixture of both fumes, the recovery time here is almost double.

5. The above is also true in cases of flies subjected first to the fumes of carbon tetrachloride and second to the fumes of ether.

6. It is safe to assume that the rate of diffusion of ether from the insect body is helped by the fumes of the fumigant bringing the insect sooner to the normal condition.

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The effect of various types of food upon the rate of development of the larvae of *Stegobium paniceum* L.

[Coleoptera : Anobiidae]

(with 10 Tables, and 2 Text-Figures)

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INTRODUCTION

One of the commonest of store-house pests is the little *Stegobium paniceum* L. which was defined by Chapman (1921), and others, as one of the most injurious and hardest to combat of all insects in stored food products because of its ability to attack a large variety of food.

The insect received its Latin name from its occurrence in dry bread, and in Europe it is still known as the « bread beetle », but its chief injuries are to druggists ; hence the name « drug-store beetle ».

The problems at present facing the entomologists demand more and more an understanding of the relation of the environmental factors to insect abundance. The length of life of any species may be increased or decreased in direct relation to the action of the surrounding medium.

One must discard any supposition that relates the development in insects to fortuitous circumstances or to adaptations readily acquired in relation to a changing or specialized type of environment. Each organism probably has its own specific rate of growth, determined largely by its genetic constitution, but subjected to great variations through the influence of the environment.

It can be stated as a fact that most if not all organisms have a characteristic duration of life. To give examples, many insects have a

duration of life measured in weeks only, as in the case of *Stegobium*, while others have a duration of life of several years, as queen ants. The question arises : What determines this characteristic duration? Temperature alone or temperature associated with atmospheric humidity play a great part in the rate of growth of any species. Variation in the developmental period of some species is largely determined by the food obtained.

In reviewing the literature the writer found only a few records of the life-cycle of the drug-store beetle *Stegobium paniceum* L.. No records have been published on the duration of each stage of the insect separately, but all the information gathered from the literature up to the present date shows that the entomologists who previously worked on *Stegobium*, such as Janisch (1923), did not record the duration of each of the larval stages separately. In other words, the exact number of the larval instars was not worked out directly (e.g., by casting skin) since the larvae disappeared within the confine of the cocoons. He stated that a certain indication of moulting may be obtained from the size of the cocoon when one animal is kept in a test-glass tube. Janisch gave the duration of the whole life-cycle of this insect from the egg till the emergence of the adult at various temperatures without stating the humidity at which his experiments were carried out. He also gave the duration of the pupal stage.

Margot (1932, *i.l.*) in determining the number of larval instars of *Stegobium paniceum* L. by measuring the head capsules of the larvae, made no attempt to rear the larvae in isolation. She stated, that once the larvae were removed from their habitats, they were difficult to rear.

However, because of the fact that the previous investigators did not rear *Stegobium* larvae singly and freely, it was attempted during the present work to raise larvae from the egg to the adult stage by keeping each larva in a separate tube and preventing it from constructing a cocoon by the methods stated here in this study. This attempt to rear the larva singly and freely met with success. Therefore, it was thought desirable to give records of the time required by the different stages of *Stegobium* and to put an end to the guesses of early authors regarding the duration of life of this insect which have been copied and recopied. Until now no records are given in the literatures except that the life-cycle of *Stegobium* is about 2 months (Chittenden 1902, Chapman 1921, and Back and Cotton 1940). The writer during his studies of the effect of temperature and humidity upon the rate of oviposition and development of *Stegobium paniceum* L. has found out that the adult does not take up food and the growth takes place during the larval stages.

It was noticed that *Stegobium* is a convenient insect for nutritional study, therefore, since no work has been done before on the nutritional

requirements of this insect and since this insect according to Back and Cotton (1940) « eats every thing except cast-iron », it was considered worth while to undertake a detailed study of the effect of various food factors upon the rate of development of the larvae of this beetle and also to determine whether its growth could be controlled experimentally and whether it could be used in nutritional work of broad biological application.

Such study would be of interest from the standpoint of comparative physiology, and would give a useful measure of the performance of this insect on various diets so that an exact understanding of its nutritional requirements may ultimately be obtained.

Food is a factor well known to affect the rate of growth of any organisms. Growth may be accelerated by certain types of natural food, dietary accessory factors or vitamins, or may be retarded by insufficient food either in quantity or quality. The constituents of food vary and the effect of food on the rate of growth of insects is greatly dependent on the kind of vitamins found in it.

Insects of widely different types have been studied and much is known already of the basic food requirements of certain insects and much valuable information has also been gathered in regard to the effect of mixed diets or diet of single food.

Northrop (1917) and Bacot and Harden (1922) reported that the two vitamins A and B, as understood in the study of vertebrate nutrition, are indispensable to *Drosophila*, and that vitamin C is not necessary.

Richardson (1926) stated that vitamin B is necessary for the growth of the Mediterranean flour moth *Ephestia kuehniella*.

In the nutrition of *Tribolium* (*Stene*) *confusum* Duv., Sweetman and Palmer (1928) found a probable need for vitamin B, though no absolutely demonstrable need for vitamin A could be detected.

Other writers suggest, that the need for vitamins may not be so urgent among insects generally as among vertebrates ; or suggest, even, that insects do not need the vitamins that vertebrates find essential.

In regard to the various natural nutrients, aside from the dietary accessory factors or vitamins, the insects as a group show extremely variable needs. Different types of food have different effects on the rate of growth of the same species.

Chapman (1922) has shown that different nutrition levels greatly affected the rate of larval development of *Tribolium* (*Stene*) *confusum* Duv.

Sweetman and Palmer (1928) gave the duration of larval life of *Tribolium* (*Stene*) *confusum* Duv. as 17 to 17.2 days on whole rice kernel (hull removed), 21.8 to 27 days on polished rice, 16.6 days on whole oat kernel (hull removed) and 14.6 days on whole barley kernel.

Good (1933) found that the entire larval development (at constant temperature and humidity) of *Tribolium* (*Stene*) *confusum* Duv. was 31 days on middling, 45.7 on bran, 64.6 on oat-meal, and 89 days on white flour. The same author found that the larvae of *Tribolium castaneum* Hbst. (= *ferrugineum* auct.) completed their development in 28.9 days on bran, 30.4 on whole-wheat flour, 31.9 on corn-meal, 32.6 on middlings, 68.2 on oat-meal, and 87.5 days on white flour.

Thomas and Shepard (1940) found that the larvae of *Oryzaephilus surinamensis* L. (at 27° C and 79% R.H.) completed development in 15.51 days on rolled oats, 18.32 on walnuts, and 30.1 days on raisins.

The general plan of the following experiments was to determine the effect of the following types of food on the duration of the life-cycle of *Stegobium paniceum* L., in days : (1) whole-meal flour, (2) oat-meal flour, (3) ground peas, (4) pea flour, (5) ground yellow maize, (6) ground polished rice, (7) ground barley, (8) meat-meal, and (9) dried milk containing 27% fat.

MATERIAL AND TECHNIQUE

Specimens of *Stegobium paniceum* L. were obtained from the Imperial College Biological Field Station at Slough (England), and were used to start cultures from which the insects utilized were selected.

Method of handling the larvae

Two cultures of *Stegobium paniceum* L. were maintained for this study on whole-meal flour, on which diet a satisfactory culture can be kept going with a minimum of attention. These cultures were kept at 25° C., and 70% R.H., and the newly emerged adults oviposited at 25° C., and 70% R.H. The flour was first sifted to remove particles which would otherwise be retained with the eggs which were readily recovered by sifting through No. 1B bolting silk cloth. The eggs obtained from these adults were transferred to empty 2 × 1 inch glass tubes, 10 eggs in each tube. These eggs were incubated at the same temperature as that where laying took place (i.e. 25° C.) with 75% R.H. in order to obtain the larvae from conditions as nearly as possible similar to those under which it was desired to study them.

The newly hatched larvae were cultured individually in 2 × 1 inches glass tubes. Only larvae hatching within a few hours of one another were used and it is assumed that the larvae were not over 12 hours old. Forty larvae were used for each kind of food. These larvae were examined under the binocular microscope after being transferred into the tubes in order to eliminate any injured animal. A separate record was kept for each larva

and observation took place every day until the individuals had reached the pupal stage. The number of larval instars was determined by actual count of the number of times individual larvae moulted before pupation. After each moult the exuviae could be seen in the small tube and were immediately removed and recorded. Because of the variation in the number of instars, the duration of the larval stages having the same number of instars was counted separately. The number of larvae which died were counted each day and the duration of life for each type of food was the average for all the larvae which completed their transformation into the pupal stage.

Food materials

The food materials selected for the developmental experiments were kept as constant as possible by always obtaining them from the same commercial source in order to bring about as uniform an original environment as possible and to avoid any possibility of variation due to differences in nutritional value from different supplies of food. Also sufficient quantities of the foods for the entire experiments were obtained at the beginning of the study.

The types of food used for the experimental studies were : whole-meal flour, oat-meal flour, ground peas, pea flour (prepared by W. Symington and Co.), ground yellow maize, ground polished rice, ground barley, meat-meal and dried milk containing 27 % fat.

Before use, the food materials were sterilized by putting them on trays one inch deep in the oven at 80 to 90° C., for six hours. This kills any pests which might be present in it, such as other harmful insects or mites. These various types of food were brought to a finely divided condition by grinding with a hand mill and were also brought into equilibrium with 75 % R.H. as shown below. The diet to be tested was sampled into 2×1 inches glass tubes and newly hatched larvae were placed singly in each tube. Enough food was placed in each tube to more than support the animal, but not enough for the larva to burrow into and became covered or to construct a cocoon. In this series of experiments the adequacy of each diet was tested in a constant physical invironment of 25° C., and 75 % R.H., by the length of larval life from hatching to pupation. No attempts have been made to use synthetic foods and no analysis of any of the foods was carried out as time did not permit.

Water content of food

The different types of food after being sterilized were placed separately in cardboard trays of $4 \times 2 \times \frac{1}{2}$ inches in desiccators at the required humidity (75 %) for at least three weeks prior to being used in order that they might

reach the relative humidity corresponding to that at which the experiments were to be carried out. The desiccators were kept at 25° C., in order that the equilibrium would be reached fairly quickly. Preliminary moisture determinations were made to find the length of time necessary to bring the foods into equilibrium with each of the required humidities. It was found that a period of 3-4 weeks is sufficient for all kinds of food to attain a constant moisture value. During this period the solution which gave the required humidity (i.e. potassium hydroxide solution in distilled water) was checked at weekly intervals or replaced by fresh solution of the same strength. The food supply was kept constant as regards the moisture content throughout the studies.

In order to measure the water content of the food, a sample of it from each desiccator was weighed, heated for about six hours at 110° C., and then weighed again. This was repeated until a constant dry weight was attained, when the moisture content was calculated.

Determination of relative humidity

To produce and maintain the desired atmospheric condition in the desiccators, a solution of potassium hydroxide (KOH) in distilled water was used.

The potassium hydroxide solution was prepared in the following proportion : percentage relative humidity, 75 ; specific gravity (15° C.), 1.202 ; ccs. H_2O, 1000 ; Gr. KOH (Approx.), 250.

The grams of KOH given above are approximate and when the solution is cool, the specific gravity is read by hydrometer and small quantities of water or KOH are added till the required specific gravity is obtained. The solution, after being made up, was kept in glass bottle tightly closed with rubber cork or glass stoppers. The strength of the solution was checked from time to time as there was a slight change in the strength of the solution probably caused by frequent opening of the bottle. This change was reversed by adding either water or KOH until the solution reached its original specific gravity.

To maintain the correct relative humidity within the desiccators during the experiments, it was found necessary for accurate results to replace the solution with fresh one every week. The necessity of replacing the solution arises because : (1) the emptying of the old solution out of the desiccators, checking it and restoring its original specific gravity causes the experimental insects within the desiccators to be exposed for a considerable time to environmental conditions different to those at which the experiments should be conducted ; (2) frequent opening of the desiccators which is necessary for daily examination also causes a slight if not big change in the strength of the solution.

Temperature

The various stages of the insect were exposed to a temperature of 25° C. either in a small cabinet or in a room controlled by toluene-mercury thermostat which did not vary more than ± 0.5-1° C.

Methods of preventing the larva from constructing a cocoon

The first larval instar of *Stegobium* feeds and develops inside a cocoon which is constructed by the larva from secretion and food. The following larval instars as they grow up, enlarge the walls of the cocoon and develop inside it until they pupate. This was noticed by J'anisch (1923) and confirmed by the writer. The disappearance of the larvae inside the cocoons made it difficult for those who previously worked on the biology of *Stegobium* : (1) to determine the exact number of the larval instars ; (2) to record the time required for the development of each instar. J'anisch (1923) who did not record the duration of the larval stages, says : « a certain indication of moulting may be obtained from the size of the cocoon when one animal is kept in a test-glass tube since no better success attends the opening of cocoons at different times ».

The writer after several attempts succeeded in breeding the larvae freely and singly and enabled the record of the duration of each larval instars as well as of the duration of the pupal stage to be made. The methods used were as follows :

(1) The food was ground very fine and the larger particles were crushed with a hand mill. It was found that large particles of food provided a suitable surface for the larvae to construct their cocoons by sticking these particles together or by finding a depression in one of the particles (husk) suitable for the building of the cocoon. Sifting the flour to remove the coarser particles is not advisable, as by removing the coarse particles, the nutritional value of the flour is reduced, since the coarse particles contain most of the growth-promoting factors.

(2) The thick layer of food encourages the larva to burrow into it and the hole through which it entered is covered with frass and secretion and the cocoon so constructed. In the small cocoon inside the medium, the larva eats from the walls and enlarges it, and moults and pupates in it. When the larva through burrowing into the medium reaches the solid wall of the glass tube, the cocoon is often stuck on to the wall, so that the wall formed a part of the cocoon. However the food was thinly spread on the bottom of the tube thus leaving the glass bottom more or less visible.

(3) The most successful method, by means of which about 90 % of the experimental larvae developed and pupated freely was as follows :

Over the bottom of the glass tube two opposite portions of flour were placed, one was thinly spread, the other was about five millimetres in height. In the latter portion a small depression was made and the newly hatched larvae transferred by a fine brush were placed in it and covered with the same particles of food and left undisturbed. In most cases the larvae ate and remained quiet for four to five days. During this time its activity was reduced by the weight of flour placed on it and this prevented it from attempting to build a cocoon. Then the flour covering the larva was removed and spread thinly all over the bottom of the tube and by this means the larva bred freely throughout larval life. In a very few cases the larva after being placed in the depression and covered with flour set itself free again and started to wander either towards the opposite thin layer of the flour which did not provide any surface for constructing a cocoon or, climbed over the wall of the tube and in the latter case it was removed by a fine brush and treated again in the same way as before until it settled down and developed freely. Very few larvae, in spite of the above treatment, were able to construct cocoons and these were dissected out carefully and the larvae were set free and then replaced on a very thin layer of flour. Usually when the first cocoon was destroyed the larva did not attempt to construct another one, but developed freely until it pupated.

RESULTS

To compare the effects of the various types of food, whole-meal flour was chosen as a control as satisfactory results were obtained on this diet.

1. Growth on a diet of whole-meal flour

Forty larvae were fed on this diet and grew quite normally. Pupation of those with 4 instars, began on the forty-second day and finished on the forty-eighth day, with an average larval life of 44.4 days. Pupation of those with 5 instars began on the forty-sixth day and finished on the fifty-fourth day, with an average larval life of 49.5 days. Pupation took place at the fourth (22 larvae) and fifth (13 larvae) moults. Thirty-five larvae reached the pupal stage and all these emerged as normal adults, representing 87.5 % of the total. Larvae fed on this diet suffered a small mortality, only 5 larvae failed to pupate, three died in the first instar, one in the second instar and one in the third instar. The cause of death was not known. Table I gives the duration of each larval instar together with the length of the whole larval life. This diet was evidently sufficient and satisfactory, as evidenced by (1) normal growth, (2) small mortality, and (3) ease in moulting.

TABLE I

The duration of each larval instar and the length of larval stage, fed on whole-meal flour, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	FIFTH	
	Larvæ of 4 Instars					
Range ..	13-16	9-12	6-8	10-14	—	42-48
Mean...	14.2	11	7.2	12	—	44.4
	Larvæ of 5 Instars					
Range ..	13-16	10-12	6-8	6-9	10-11	46-54
Mean...	14	10.7	6.5	8	10.3	49.5

2. Growth on a diet of oat-meal flour

Forty larvae were fed on this diet which was nearly as satisfactory as whole-meal flour, but the larvae took a little longer to complete their development. The pupation of larvae of 4 instars began on the forty-fourth day and finished on the fifty-third day, with an average larval life of 48.3 days,

TABLE II

The duration of each larval instar and the length of larval stage, fed on oat-meal flour, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	FIFTH	
	Larvæ of 4 Instars					
Range ..	10-14	10-13	8-16	13-22	—	44-53
Mean. .	11	11.6	9.9	15.8	—	48.3
	Larvæ of 5 Instars					
Range ..	10-11	12-13	9-10	11-13	13-14	56-59
Mean...	10.5	12.2	9.2	12.5	13	57.4

while the pupation of the larvae of five instars began on the fifty-sixth day and finished on the fifty-ninth day, with an average larval life of 57.4 days. Pupation took place at the fourth (28 larvae) and fifth (6 larvae) moults. Thirty-four larvae reached the pupal stage, thirty-two of these emerged as normal adults, representing 80% of the total. Mortality on this diet was

slightly higher than that on the whole-meal flour. Eight individuals died, 2 as pupae near the emergence of the adults, 4 as larvae while pupating and 2 as larvae in the fourth instar. The duration of each larval instar and the length of the whole larval stage are arranged in Table II.

It seems from the figures in Table II that the duration of the first three stages of each of the larvae of 4 or 5 instars did not differ significantly. The third instar seemed to be the shortest, while the last stage of larvae of 4 instars required longer time. For the larvae of 5 instars, there was no significant difference between the second, fourth and fifth instars, while the third and the first larval instar required comparatively less time.

3. Growth on a diet of ground peas

Forty larvae were fed on this diet. Of all the types of food used, this seemed one of the most satisfactory diets. The rate of larval development was noticeably accelerated; the first pupation (larvae of 4 instars) occurred on the thirty-second day and the last on the forty-first day, with an average length of larval life of 35.8 days. Pupation of the larvae of 3 instars began on the thirty-second day and the last on the forty-first day, with an average length of larval life of 38.7 days. Pupation took place on the third (3 larvae) and fourth (35 larvae) moults. Ninety-five per cent of the larvae reached pupation and all emerged as normal adults. It is interesting to note that the adults of 4 larval instars were larger than those with the same number of instars whose larvae were fed on either whole-meal flour or oat-meal flour. Only 2 out of 40 larvae used, died during the first instar, the mortality being 5% on this diet. The duration of the larval instars is given in Table III.

TABLE III

The duration of each larval instar and the length of larval stage, fed on ground peas, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS				LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	
	Larvæ of 4 Instars				
Range ...	8-11	6-11	6-8	10-13	32-41
Mean	9.4	7.8	7	11.6	35.8
	Larvæ of 3 Instars				
Range ...	9-10	8-10	19-21	—	36-41
Mean	9.4	9	20	—	38.7

From the figures in Table III, it appeared that the larvae of 3 instars completed their development in longer time than those having 4 larval instars. This variation in the length of development was caused by the prolongation of the growth of the last stage (3rd instar) which required an average of 20 days to reach the pupal stage as compared with 7 days required for the third stage of the larvae of 4 instars. There was no significant difference in the growth rate of the first two stages of the larvae of 3 instars but the first stage of larvae of 4 instars was little longer than the second and the third stages of the larvae of the same number of instars.

4. Growth on a diet of pea flour

Forty larvae were fed on this diet. Of all the diets used, the pea flour (prepared by W. Symington and Co.) like the ground peas seemed one of the most satisfactory diets for this species. The larvae grew quite normally and very rapidly, larval life being significantly shorter than on any of the diets used. Pupation began on the thirty-second day and finished on the fortieth day, with an average larval life of 35.5 days. Pupation took place at the fourth moult only. Thirty-nine out of forty larvae reached pupation and all these emerged as adults, representing 97.5 % of the total. Only one larva died in the third instar. The duration of the larval instars in shown in Table IV.

TABLE IV

The duration of each larval instar and the length of larval stage, fed on pea flour, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS				LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	
Range ...	9-13	7-9	6-9	10-14	32-40
Mean	9.4	7.5	7.1	11.5	35.5

It will be seen from the figures in Table IV that there was no significant variation in the length of the second and the third instars while the first and the fourth instars required a longer time. These results made it evident that the pea flour like peas was superior to any type of food used, since (1) the rate of growth of the larvae was the shortest, (2) 97.5 % larvae reached adult stage, (3) no significant variation between the range and the mean length of development of each instar, and (4) ease in moulting.

5. Growth on a diet of ground yellow maize

Forty larvae were fed on this diet. Yellow maize was about as satisfactory as ground peas as a single food for this species. The larval development was a little longer on this diet than on peas but shorter than on whole-meal flour or oat-meal flour. The growth was normal and pupation only took place on the fourth moult. Pupation began on the thirty-sixth day and lasted until the forty-fifth day, with an average larval life of 39.7 days. Thirty-nine out of 40 larvae reached pupation and all emerged as normal adults, this representing 97.5 % of the total. Only one larva died while being transformed into the pupal stage. The duration of the larval instars is summarized in Table V.

TABLE V

The duration of each larval instar and the length of larval stage, fed on ground yellow maize, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS				LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	
Range ...	10-13	6-8	8-10	11-14	36-45
Mean	11.7	6.8	8.9	12.3	39.7

On this diet it seemed that the second instar was the shortest and not the third instar as found in the previous larval foods. The time required for the growth of the first instar was nearly equal to that needed for the fourth instar.

6. Growth on a diet of ground polished rice

Forty larvae were fed on this diet. From the results obtained below it seemed that rice was not satisfactory as a sole diet for this insect. Development was noticeably retarded and the rate of growth was no longer normal. Pupation took place at the fifth, sixth, seventh, and eighth moults but never at the fourth. The first pupation occurred on the sixty-fourth day (for the larvae of 5 instars) and ended on the one hundred and fiftieth day (for the larvae of 8 instars). The rate of growth of the different larval instars is shown in Table VI.

It will be seen from the figures in Table VI that the first 5 instars in each case did not differ significantly in their rate of growth. A slight variation occurred in the duration of the latter stages (i.e. from the sixth

TABLE VI

The duration of each larval instar and the length of larval stage, fed on ground polished rice, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS								LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	EIGHT	
					Larvæ of 5 Instars				
Range..	15-19	9-12	9-12	12-14	15-19	—	—	—	64-69
Mean...	17	10	10.7	13	17	—	—	—	67.7
					Larvæ of 6 Instars				
Range..	14-19	9-13	8-13	10-17	16-29	11-26	—	—	78-101
Mean...	16	10.5	10.9	14	22	19.3	—	—	92.7
					Larvæ of 7 Instars				
Range..	15-17	10-12	11-12	11-13	19-21	18-19	15-18	—	99-112
Mean...	16	11	11.5	12	20	18.5	16.5	—	105.5
					Larvæ of 8 Instars				
Range..	13-19	10-11	10	14-16	16-21	25-30	19-30	19-22	135-150
Mean...	16	10.5	10	15	18.5	27.5	24.5	20.5	142.5

to the eighth instars). Out of the forty larvae used, 4 had five instars, 19 had six instars, 2 had seven instars, and 4 had eight instars. Altogether twenty-nine larvae reached pupation and all these emerged as normal adults, this representing 72.5 % of the total. The mortality was high on this diet, eleven larvae died, 4 in the first instar, 2 in the third instar, 2 in the fourth instar, and 3 in the sixth instar.

7. Growth on a diet of ground barley

Forty larvae were fed on this diet. Barley was about as satisfactory as maize but the larvae had more moults. The larvae of 4 instars fed on barley showed more rapid rate of growth than those fed on either whole-meal flour or oat-meal flour. The duration of the entire life of larvae of 5 instars fed on this diet was the same as that of the larvae of 5 instars which fed on oat-meal flour, the averages being 57.3 and 57.4 days respectively. Pupation took place on the fourth (24 larvae), fifth (6 larvae), and sixth (4 larvae) moults. There was an indication of a seventh moult on this diet since two larvae died after having passed through the sixth instar. Pupation first occurred on the thirty-seventh day (for larvae of 4 instars), on the fifty-fourth day (for larvae of 5 instars) and on the seventy-ninth

day (for larvae of 6 instars) and the last on the forty-fourth, sixty-third and eighty-fourth day (for the larvae of 4, 5, and 6 instars respectively). The average length of larval life being 41.2 days (4 instars), 57.3 days (5 instars), and 81 days (6 instars). Thirty-four larvae out of 40 reached pupation and all these emerged as normal adults, this representing 85% of the total. Six larvae died, one in the third instar, one in the fourth instar, two in the fifth instar and two after the sixth instar. The length of life of the larvae of different instars is given in Table VII.

TABLE VII

The duration of each larval instar and the length of larval stage, fed on ground barley, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS						LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	
	Larvæ of 4 Instars						
Range..	8-12	7-11	7-10	10-16	—	—	37-44
Mean...	9.6	9	8.6	14	—	—	41.2
	Larvæ of 5 Instars						
Range..	11-13	8-9	9-11	10-12	14-20	—	54-63
Mean...	11.5	8.5	10	10.8	16.5	—	57.3
	Larvæ of 6 Instars						
Range..	10-11	8-10	10-11	12-15	22-25	14-15	79-84
Mean...	10.3	9.3	10.4	13	23.7	14.3	81

It is clear from the figures in Table VII that the duration of the larval instars from the first to the fourth did not differ significantly in the three types and the prolongation of life of larvae of 5 and 6 instars was apparently due to the first having one and the second two more moults than the larvae of 4 instars.

8. Growth on a diet of meat-meal

Forty larvae were fed on this diet. Mould growth occurred quite frequently on this food and in order to eliminate this, the diet was changed every three days. The larvae fed on meat-meal required a longer time for growth than those fed on whole-meal flour, ground peas, yellow maize, barley and pea flour. On the other hand the growth of these larvae was more rapid than that of the larvae fed on either oat-meal flour, rice or dried milk. The larvae suffered high mortality; eleven died, six in the first instar,

one in the second instar, two in the fourth instar, two in the pupal stage (one of them died while emerging into the adult stage). Twenty-nine larvae reached pupation and all these emerged as normal adults, representing 72.5 per cent of the total. The larvae had four (18 larvae) and five moults (11 larvae). The first pupation occurred (larvae of 4 instars) on the forty-third day and on the forty-ninth day (larvae of 5 instars), and the last on the fifty-second and fifty-ninth day for the larvae of 4 and 5 instars respectively, with an average larval life of 46.2 and 54.2 days. Moulting was not as easy as it was in the case of the larvae fed on the other kinds of food, since the skin remained attached to the body of some larvae for one or two days after every moult. The duration of the larval instars is arranged in Table VIII.

TABLE VIII

The duration of each larval instar and the length of larval stage, fed on meat-meal, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	FIRST	SECOND	THIRD	FOURTH	FIFTH	
	Larvæ of 4 Instars					
Range..	10-12	8-17	10-12	12-20	—	43-52
Mean...	10.5	9.4	10.8	15.5	—	46.2
	Larvae of 5 Instars					
Range..	11-14	8-10	9-11	8-10	11-16	49-59
Mean...	11.8	9	10.2	9.4	13.8	54.2

It is clear from the figures in Table VIII that the mean rate of growth of the first 3 stages of the larvae of 4 or 5 instars did not differ significantly, but there was a slight variation in the rate of growth of the last instar in each case. This food was not satisfactory for this species as a single food, as evidenced by (1) high mortality, and (2) difficulty in moulting.

9. Growth on a diet of dried milk (containing 27 % fat)

Forty larvae were fed on this diet. Mould growths developed rapidly on this diet, so the food was changed every two or three days. Dried milk alone proved unsatisfactory as a diet for this insect. Only four individuals were reared through the adult life, representing 10% of the total. Thirty-five larvae and one pupa did not complete their life and the majority of larvae (30 larvae) died before the first moult, and the remaining five died

after passing through the first instar, and one died as pupa before the emergence of adult. The larvae which reached the adult stage pupated at the fifth (3 larvae) and the sixth (one larva) moults. Pupation of the larvae of 5 instars did not begin until the sixty-third day and was prolonged to the seventy-ninth day, with an average larval life of 69.6 days. The pupation of the larva which had 6 instars took place on the seventy-seventh day.

TABLE IX

The duration of each larval instar and the duration of larval stage, fed on milk and on milk with yeast, and kept at 25° C. and 75 % R.H.

(40 larvae used for each diet)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS	NUMBER OF LARVÆ REACHED ADULT STAGE
	FIRST	SECOND	THIRD	FOURTH	FIFTH		
	Fed on milk (27 % fat)						
Range ..	16-18	9-11	10-12	0-10	18-29	63-79	4*
Mean...	17	9.7	10.6	10	22.3	69.6	
	Fed on milk + 10 % yeast						
Range ..	14-17	8-12	9-12	8-10	16-25	56-70	24
Mean...	15.2	8.7	9.3	8.5	19.6	61.3	

* One larva out of this number had 6 instars

The high mortality on a diet of milk was probobly due to one or more of the following factors: (1) the absence of some growth-promoting substances in the milk which are necessary for the growth of *Steyobium* larvae, (2) the high fat content of the milk (27 %) might be unfavourable for the growth of the larvae, and (3) fat did not absorb water (unhygroscopic) and thus the high death rate might be caused by the dry condition of the milk.

The first factor (the absence of some substances necessary for growth) was analysed by adding 10 % dried brewers' yeast to the milk to find out whether more larvae would be reared on this mixture. Time did not permit to find out whether the amount of fat present in the milk was responsible for the death of the larvae. This could be done by extracting the fat from the milk and then feeding the larvae on the residue.

The addition of 10 % yeast to the milk did not only permit more rapid growth but also decreased the mortality. Twenty-four larvae out of 40 fed on milk with 10 % yeast added reached pupation and all these emerged as normal adults. Pupation on this diet took place at the fifth moult only,

while those fed on milk alone pupated at the fifth and the sixth moults. Pupation of the larvae fed on the mixture of yeast and milk occurred on the fifty-sixth day and the last on the seventieth day, with an average time of 61.3 days as compared with 69.6 days the average time required for the larvae (of 5 instars) fed on milk alone. The development of the larvae fed on milk alone and milk with 10% yeast is given in Table IX for comparison.

This experiment suggests that the addition of yeast to the milk supplied the larvae with substances necessary for growth which were probably not present in sufficient quantities in dried milk, such as vitamin B which is found in milk in a small amount.

A summary of data of the effect of various types of food on the larval stage, the number which survived on each diet, and the total duration of the life-cycle of the adult (male and female) is represented in Table X, and

TABLE X

A summary of data of rearing larvae (of 4 instars) of Stegobium paniceum *L. on various diets, as well as the total duration of the life-cycle of the adult, at 25° C. and 75 % R.H.*

(40 larvae used)

DIET	LARVÆ REACHING ADULT STAGE		AVERAGE DURATION IN DAYS		TOTAL DURATION OF ADULT IN DAYS (2)
	NUMBER (1)	PERCENTAGE	LARVÆ	PUPÆ	
Whole-meal flour	35	87.5	44.4	7	51.4
Oat-meal flour	32	80	48.3	7.1	55.4
Ground peas	38	95	35.8	7	42.8
Yellow maize	39	97.5	39.7	7.2	46.9
Polished rice (3)	29	72.5	none	none	—
Barley	34	85	41.2	7	48.2
Meat-meal	29	72.5	46.2	6.9	53.1
Pea flour	39	97.5	35.5	7.4	42.9
Dried milk (27 % fat) (4)	4	10	none	none	—

(1) This number included the number of larvae which completed their life to the adult stage regardless of their number of instars.

(2) The total duration of the life-cycle of adult was reckoned from time the larvae hatched to the emergence of adult.

(3) Only larvae of 5, 6, 7, and 8 instars occured (average length of larvae of 5 instars was 67.7 days).

(4) Only larvae of 5 and 6 instars occured.

the duration of development of the larvae of 4 and 5 instars is illustrated in Figure 1. The duration of larvae of 4 instars only were given for the purpose of comparison between the effect of different types of food, since

this number (4 instars) is normal and also these larvae occurred mostly on the various types of food and in some cases all the larvae fed on a particular food had only 4 instars. The percentage of larvae reaching adult stage (regardless of the number of instars) is shown in Figure 2.

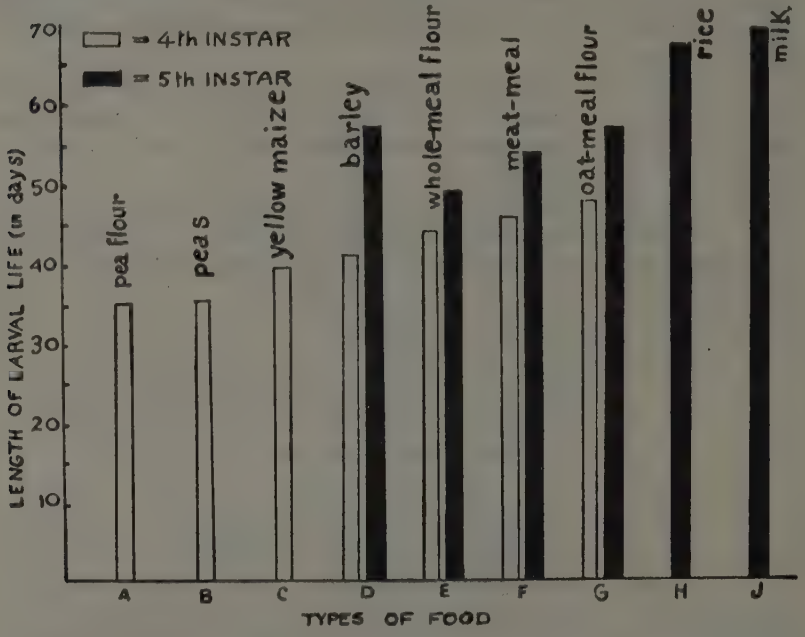

Fig. 1 : Effect of various foods on the duration of larval life in 4th and 5th instars of *Stegobium paniceum* L. at 25° C. and 75 % R.H.

DISCUSSION

It is evident that the study of the effect of the various types of food on the development of the larvae of *Stegobium* does not reveal the identity of a limiting factor. All the writer can say is that some more or less quantitative or qualitative deficiency is indicated by comparison of results.

From Table X, and Fig. 1, it is clear that the good development of the larvae as shown by (a) normal growth, (b) lower mortality, (c) shorter larval life, on the single diets of whole-meal flour, oat-meal flour, ground peas, pea flour, ground yellow maize, and ground barley shows that such single diets are clearly sufficient and satisfactory for this species.

On the basis of the shortest rate of development accompanied by lowest mortality, pea flour and the ground peas are superior to the other single

diets used. On the same basis, yellow maize comes third in superiority, then barley, whole-meal flour and lastly oat-meal flour.

The relatively poorer development, irregular growth and high mortality of the larvae on such single diets as ground polished rice, meat-meal and particularly dried milk containing 27 % fat, show that these are unsatisfactory diets for this species.

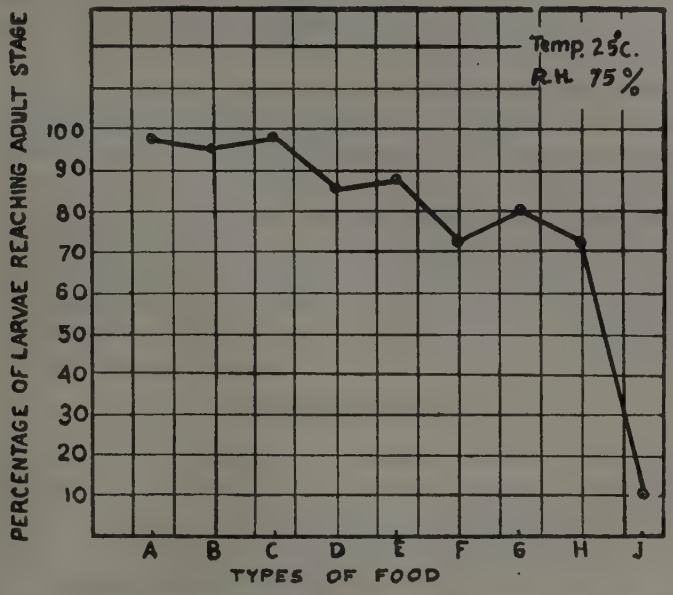

Fig. 2 : Percentage of larvae of *Stegobium paniceum* L. reaching adult stage on various foods (foods A to J as in Figure 1).

Polished rice (or endosperm alone) shows the greatest prolongation of larval life. On this diet the first larva (of 5 instars) required 64 days to reach pupation and the last larva reaching pupation in a length of time of 150 days (larvae of 8 instars). It is remarkable that this diet permits a fair percentage of pupation in spite of the belief that the polished rice entirely lacks vitamin B (McCollum and Davis 1915, and Sherman 1937), but such results obtained on this diet are probably evidence that the larvae of *Stegobium* can exist on a low level of vitamin B. A similar case was reported by Sweetman and Palmer (1928) on feeding larvae of *Tribolium* (*Stene*) *confusum* Duv. on polished rice.

Dried milk (27% fat) is wholly unsatisfactory as a sole diet for this species as evidenced by: (1) very high mortality, and (2) prolongation of growth. By adding dried brewers' yeast to the milk, not only the growth

of the larvae becomes more rapid but also the rate of mortality is decreased. This suggests that yeast supplies the milk with growth-promoting substances (such as vitamin B) which are absent or not present in sufficient quantities in milk. The poor results obtained on milk may be also due to the high content of fat in the milk which is presumably unfavourable for growth of the larvae, or because of the dry condition of the milk owing to the fat being unhygroscopic. Neither of these two latter factors were studied.

The length of the pupal stage remains the same (Table X) no matter what kind of food the larvae are fed on.

Four or five larval instars are typical for both sexes of this species, with an occasional individual exhibiting an extra one, two or three instars. The variation in the number of instars with different foods was as follows:

Polished rice (5-8 instars), milk (5-6 instars), meat-meal (4-6 instars), barley (4-6 instars), whole-meal flour and oat-meal flour (4-5 instars). With the diets yellow maize and pea-flour, the larvae only have 4 instars, but with the ground peas the larvae have 3 and 4 instars. From these results it is evident that food is partly responsible for this variation in number of instars.

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The influence of yeast upon the rate of development of the larvae of *Stegobium paniceum* L.

[Coleoptera : Anobiidae]

(with 1 Text-Figure, and 9 Tables)

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INTRODUCTION

Although much valuable information has been gathered by the writer in regard of the effect of various types of single food on the rate of development of the larvae of *Stegobium*, there is still a need for information about accessory substances or vitamins which affect the rate of growth of the larvae of this insect. Not all animals respond equally to a given concentration of a vitamin-containing preparation, the amount necessary for growth, maintenance and reproduction varying considerably, in some cases, from species to species.

Of the vitamins now recognised as essential for the growth of higher animals, probably only two exist in an active condition in the wheat kernel, namely vitamin A and vitamin B. Dry cereals apparently do not possess vitamin C in an active state.

In reviewing the literature, it has been found that the addition of yeast to the diets of some insects accelerates the rate of growth of the larvae. Yeast is described by many authors, as a source of growth-promoting factors and in particular a source of vitamin B. Northrop (1917) reported that yeast is the richest source of vitamin B which is essential for the growth of insects.

Of insects thus studied, the fruit fly, *Drosophila melonogaster*, has received most attention. This species normally lives upon decaying fruit, but Delcourt and Guyenot (1911) have reported a method of securing aseptic colonies reared upon potato and dead bakers' yeast while the potato alone produced few, stunted and sterile adults.

Guyenot (1913, and 1917) has shown, in a very careful series of experiments, that no artificial food for *Drosophila* is complete unless the substances contained in the filtered autolysate of yeast are added to it. He concludes that it is a vitamin of yeast, the absence of which retards the development of the larvae and causes their death.

Northrop (1917) found that the larvae of *Drosophila* cannot grow on glucose-agar unless yeast is added. He believes that the yeast plant supplies *Drosophila* larvae with growth-promoting substances similar to vitamins, which the plant is able to synthesize from simple chemical compounds. Northrop stated, that a deficiency in yeast caused a retardation of growth during the larval period of *Drosophila*. The same author stated that he was able to rear *Drosophila* on yeast alone.

The work of Baumberger (1917, and 1919) may be cited also in connection with the rearing of *Drosophila* upon diets containing varying amounts of yeast. It was found that when media were made up containing varying amounts of yeast, the rate of growth of the larvae was proportional to the amount of yeast in the medium. The greatest size was attained in a medium containing 24% of yeast. Baumberger suggested that the effect of the yeast may at least partly be due to the synthesis of proteins by the yeast cells. The same author reported that he reared *Drosophila* on yeast alone.

Richardson (1926), in a very careful and detailed study of the feeding requirements of the Mediterranean Flour Moth, *Ephestia kuehniella* Zell., finds that highly milled patent wheat flour causes a retardation in the growth of larvae, and a diminution in the weight of the resulting moths. The addition of the alcoholic extract of yeast to that flour increased the rate of growth and the weight of the emerging moths. Deficiency of highly milled flour for growth purposes would seem therefore to depend upon the low concentration of vitamin B, since the addition of yeast extract improves the growth value. The normal source of vitamin B appears to be largely in the embryo of the wheat kernel.

Herford (1931) carried out experiments to test the effect of yeast on the length of life of *Laemophloeus turcicus* Grouv. He came to the conclusion that the addition of yeast to a diet of whole-meal flour both accelerated the process of development and increases the survival potential of this insect.

Bushnell (1938) studied the relation of nutritional levels to the growth of population of *Tribolium confusum* Duv. He found that the population grew faster and reached a higher level when dried brewers' yeast was added to culture medium of yellow corn-meal than in the culture medium of yellow corn-meal alone.

Gay (1938) demonstrated experimentally the effect of the addition of yeast to a prepared diet for the larvae of *Dermestes vulpinus* F. He found that the 10% and 5% yeast cultures are reasonably comparable and any reduction of the yeast content below 5% causes a prolongation of the growth period and excessive mortality. He found that the larvae fed on a mixed diet containing 10% yeast had an average length of larval life of 27.3 days as compared with 29.2 days required for those fed on the same diet added to 5% yeast.

It seemed of importance, therefore, to determine whether in the case of *Stegobium* the yeast was needed to supply some accessory food substances and whether the larvae of this insect would live on yeast exclusively.

METHOD AND TECHNIQUE

The culture media of whole-meal flour and whole-meal flour supplemented with yeast were selected. These culture media were brought into equilibrium with 75% R.H. (by using potassium hydroxide solution in distilled water). In the series of experiments presented here 4 cultures were set up, (A) one, containing all whole-meal flour, (B) the same flour with 10% dried brewers' yeast powder (obtained from Glaxo Laboratories), (C) flour with 20% yeast, and (D) all yeast.

Method of handling the larvae

Two cultures of *Stegobium paniceum* L. were maintained for this study on whole-meal flour. One culture was kept at 25° C., and 70% R. H. and the newly emerged adults oviposited at 25° C., and the other culture was kept at 30° C. and 70% R. H. The eggs obtained from these adults at different temperatures, were removed and transferred to empty 2 × 1 inches glass tubes, 10 eggs in each tube. These eggs were incubated at the same temperatures as those where laying took place (with 75% R. H. for all the temperatures used) in order to obtain the larvae from conditions as nearly as possible similar to those under which it was desired to study them. The newly hatched larvae were cultured individually in 2 × 1 inches glass tubes. Only larvae hatching within a few hours of one another were used and it is assumed that the larvae were not over 12 hours old. A group of forty

2×1 inches tubes with one larva in each tube were used in the cultures A, B, C and D. The experiments were conducted at 25° C. and 30° C. with 75% R. H.

RESULTS

The mixtures which contain whole-meal floor and yeast in the proportions of 10 and 20% yeast by weight are hereafter referred to as 10% and 20% yeast mixtures.

The following series of experiments were carried at 25° C., and 75% R. H.

A. Growth on a diet of whole-meal flour alone

Forty larvae were fed on this diet and grew quite normally. Pupation of those with 4 instars, began on the forty-second day and finished on the forty-eighth day, with an average larval life of 44.4 days. Pupation of those with 5 instars began on the forty-sixth day and finished on the fifty-

TABLE I

The duration of each larval instar and the length of larval stage, fed on whole-meal flour, and kept at 25° C. and 75 % R.H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	First	Second	Third	Fourth	Fifth	
	Larvae of 4 instars					
Range ..	13-16	9-12	6-8	10-14	—	42-48
Mean...	14.2	11	7.2	12	—	44.4
	Larvae of 5 instars					
Range ..	13-16	10-12	6-8	6-9	10-11	46-54
Mean...	14	10.7	6.5	8	10.3	49.5

fourth day, with an average larval life of 49.5 days. Pupation took place at the fourth (22 larvae) and fifth (13 larvae) moults. Thirty-five larvae reached the pupal stage and all these emerged as normal adults, representing 87.5% of the total. Larvae fed on this diet suffered a small mortality, only 5 larvae failed to pupate, three died in the first instar, one in the second instar and one in the third instar. The cause of death was not known, Table I gives the duration of each larval instar together with the length of the whole larval life. This diet was evidently sufficient and satisfactory, as evidenced by (1) normal growth, (2) small mortality, and (3) ease in moulting.

B. Growth on a diet of 10 % yeast mixture

Forty larvae were reared on a mixture of whole-meal flour and 10% dried brewers' yeast. Growth on this mixture was quite satisfactory, the larvae completed their development in a time which was a little shorter but not very significantly as compared with those fed on whole-meal flour without yeast. Pupation of the larvae of 4 instars began on the thirty-eighth day and continued to the fifty-second day, the average length of larval life being 42 6 days as compared with 44.4 days the average length of life of the larvae fed on flour only.

The larvae fed on 10% yeast mixture pupated at the same moults as those fed on flour alone (i.e. at the fourth and the fifth moults), but more of the larvae had four moults (34 larvae) on this mixture than those fed on whole-meal flour (22 larvae). Only 3 larvae fed on this mixture had five moults as compared with 13 larvae fed on whole-meal flour which had five moults. The pupation of the larvae having 5 instars (fed on 10% yeast mixture) began on the forty-fourth day and finished on the fifty-first day with an average length of larval life of 46.9 days as compared with 49.5 days required by the larvae of the same number of instars and fed on whole-meal flour only. On this mixture 37 larvae out of 40 succeeded in pupating and all emerged as normal adults, representing 92.5% of the total (87.5% of larvae fed on flour alone had reached adult stage). Only 3 larvae fed on this mixture died at the first instar. The duration of each of the larval instars reared on this mixture is given in Table II, and the average length of larval life (of 4 and 5 instars) is illustrated in Figure 1.

C. Growth on a diet of 20 % yeast mixture

As the larvae grew little faster on whole-meal flour containing 10% yeast than on whole-meal flour alone, the percentage of yeast in the mixture was increased. Accordingly forty larvae were fed on a mixture of whole-meal flour with 20% yeast added to it. With this mixture the larvae grew normally and more raipdly than the larvae which either fed on whole-meal flour without yeast or on whole-meal flour added to 10% yeast. Pupation (of larvae of 4 instars) began on the thirty-fifth day and finished on the forty-seventh day, with an average length of larval life of 39.5 days as compared with 42.6 days (for larvae fed on 10% yeast mixture) and 44.4 days (for larvae fed on flour alone). Thirty-seven larvae pupated at the fourth moult and only two larvae (with an average larval life of 45.5 days) pupated at the fifth moult. Thirty-nine larvae out of forty reached pupation and all these emerged as normal adults, representing 97.5% of the total. Only one larva died in the first instar. The length of each larval

instar is given in Table II, and the average length of larval life (of 4 and 5 instars) is represented in Figure 1.

D. Growth on a diet of 100 % yeast

This experiment was undertaken to find out whether the larvae of *Stegobium* could be reared on a diet of yeast alone. Forty larvae were fed on this diet but mould growths occurred quite frequently. This was eliminated by changing the yeast whenever mould occurred. This diet proved

TABLE II

Summary of results of rearing larvae of Stegobium paniceum *on various diet mixtures, at 25° C. and 75 % R.H.*

(40 larvae used for each diet)

DIETS	NUMBER OF LARVAE REACHED PUPATION		DURATION OF LARVAL INSTARS IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
			First	Second	Third	Fourth	Fifth	
Larvae of 4 instars								
Whole-meal flour	22	Range	13-16	9-12	6-8	10-14	—	42-48
		Mean	14.2	11	7.2	12	—	44.4
Whole-meal flour + 10 % yeast.	34	Range	8-13	7-9	8-12	15-20	—	38-52
		Mean	11.1	7.6	9.6	14.3	—	42.6
Whole-meal flour + 20 % yeast.	37	Range	9-14	6-9	7-12	11-20	—	35-47
		Mean	11	7.1	8	13.3	—	39.5
All yeast	2	Range	20-22	12-14	14-16	32-37	—	78-89
		Mean	21	13	15	34.5	—	83.5
Larvae of 5 instars								
Whole-meal flour	13	Range	13-16	10-12	6-8	6-9	10-12	46-54
		Mean	14	10.7	6.5	8	10.3	49.5
Whole-meal flour + 10 % yeast.	3	Range	12-14	8-9	5-8	7-8	11-14	44-51
		Mean	13.3	8.3	6.3	7.5	11.7	46.9
Whole-meal flour + 20 % yeast.	2	Range	9-13	7-9	5-9	7-9	11-12	42-49
		Mean	11	8	7	8	11.5	45.5
All yeast(1)	15	Range	19-21	12-19	14-24	16-28	15-32	90-106
		Mean	20	15.3	18	22	24	99.3

(1) Another 8 larvae fed on this diet had 6 instars.

unsatisfactory as a sole diet for this species as evidenced by (1) abnormal growth of larvae, (2) a significant lengthening of the growth period, and (3) an increase in mortality. Pupation did not begin until the seventy-eighth day (larvae of 4 instars) and was prolonged to one hundred and sixteenth day (larvae of 6 instars) with an average larval life of 83.5 days

(for larvae of 4 instars), 99.3 days (for larvae of 5 instars) and 113.4 days (for larvae of 6 instars). Pupation took place at the fourth (2 larvae), fifth (15 larvae) and sixth (8 larvae) moults. Twenty-five larvae out of forty reached the pupal stage and twenty-three of these emerged as normal

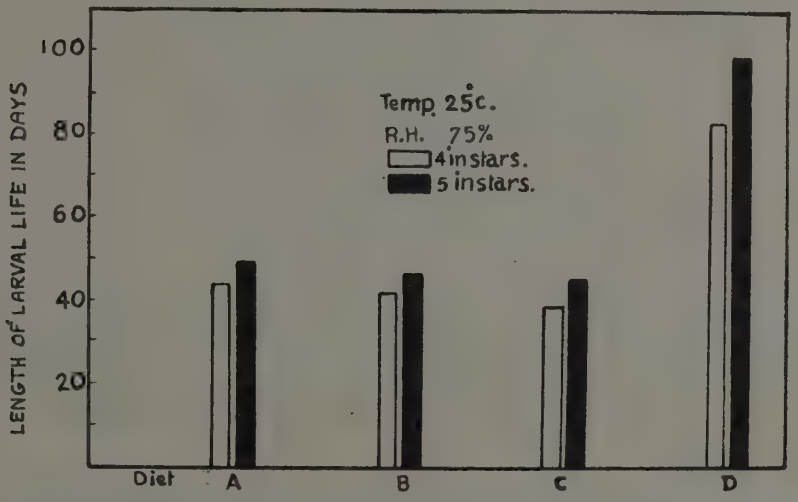

Fig. 1 : Influence of yeast on the duration of larval life of 4 and 5 instars of *Stegobium:* (A) whole-meal flour, (B) whole-meal flour + 10 % yeast, (C) whole-meal flour + 20 % yeast, (D) all yeast.

adults, representing 57.5 % of the total. Fifteen larvae failed to complete their development, 8 died during the first instar, 5 died during the second instar and 2 died after the fifth instar. Two pupae dried up and died before transforming into the adult stage. The mortality was thus 42.5 %. The duration of each larval instar (of larvae of 4 and 5 instars) is shown in Table II, and the average length of larval life (of 4 and 5 instars) is included in Figure 1.

TABLE III

DIET		DURATION OF EACH LARVAL INSTAR IN DAYS						LENGTH OF LARVAL STAGE IN DAYS
		First	Second	Third	Fourth	Fifth	Sixth	
All yeast	Range .	20-21	11 12	11-12	17-19	21-35	20-30	110-121
	Mean . :	20.2	11.3	11.3	17.6	29	24	113.4

Since the larvae of six moults only occurred on the diet of yeast alone, it is convenient to represent the duration of each of the six larval instars separately in Table III.

The results of the foregoing experiments are summarized in Table II, which shows the average lengths of larval life, duration of instars and number of moults on the different diets.

It is interesting to note that there was a significant rapidity in the growth rate of the larvae of 4 instars (fed on 10% and 20% yeast mixtures) during the first two instars, while the third and fourth moults developed in a little longer time than the developmental time required by the third and fourth larval instars fed on whole-meal flour alone. This meant that the effect of yeast was on the earlier stages rather than on the later ones. In the case of the larvae of 5 instars which fed on the same yeast mixtures, there was a little increase in the growth rate of the first four instars, while the last instars required somewhat longer time to reach pupation than those fed on flour alone. On the other hand, the data in Table II, clearly show that the 10% and 20% yeast mixtures produced a shortening in the growth period of the larvae with only a very low mortality and the diet of whole-meal flour caused comparatvely little prolongation in the larval life and a slightly higher percentage of mortality. The rate of development of the larvae fed on yeast alone was noticeably retarded and the data show a considerable variation in the duration of larval instars as well as a very high mortality.

The following experiments carried out at 30° C., and 75% R.H. are exactly like the preceding ones except for the different temperature

A. Growth on a diet of whole-meal flour alone

Forty larvae were reared on this diet. Table IV, shows the duration of larval instars as well as the average lengths of larval life of larvae which fed on this diet. Pupation occurred on the thirty-sixth day for the larvae of 4 instars and on the fortieth day for the larvae of 5 instars and finished on the forty-third and forty-eighth day for the larvae of 4 and 5 instars respectively. The average length of larval life was 39.2 (for larvae of 4 instars) and 45 days (for larvae of 5 instars). Thirty-four larvae reached pupation and all emerged as normal adults, representing 85% of the total. Five larvae died and one pupa failed to transform into the adult stage.

B. Growth on a diet of 10% yeast mixture

Forty larvae were fed on this mixture and they grew normally as on whole-meal flour alone, but with a silght shortening of development. The first pupation of larvae of 3 instars began on the twenty-seventh day and the last on the thirty-fourth day, with an average larval life of 31.1 days. Pupation of larvae of 4 instars occurred on the thirty-second day and finished

on the thirty-ninth day, with an average larval life of 36.1 days as compared with 39.2 days required for the larvae fed on whole-meal flour alone to complete their larval life (the comparison took place here for the larvae

TABLE IV

The duration of each larval instar and the length of larval stage, fed on a diet of whole-meal flour alone, and kept at 30° C. and 75 % R. H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	First	Second	Third	Fourth	Fifth	
			Larvae of 4 instars			
Range ..	10-13	7-10	5-8	13-16	—	36-43
Mean...	10.7	8.2	6.1	14.2	—	39.2
			Larvae of 5 instars			
Range ..	8-11	6-9	4-8	6-8	13-16	40-48
Mean...	10.1	8.2	5.7	7.3	13.7	45

of 4 instars only, since no larvae of 3 instars occurred on the diet of flour alone). Thirty six larvae fed on this mixture reached pupation and all emerged as normal adults, representing 90 % of the total (85 % of the larvae

TABLE V

The duration of each larval instar and the length of larval stage, fed on 10 % yeast mixture, and kept at 30° C. and 75 % R. H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS				LENGTH OF LARVAL STAGE IN DAYS
	First	Second	Third	Fourth	
			Larvae of 3 instars		
Range .	4-6	7-14	11-20	—	27-34
Mean..	5.1	10.2	15.8	—	31.1
			Larvae of 4 instars		
Range .	5-8	6-11	5-12	11-16	32-39
Mean..	7	7.9	7.6	13.6	36.1

fed on flour alone reached pupation). Twenty-two larvae pupated at the fourth moult and 14 larvae pupated at the third moult. Only 4 larvae died, 2 in the first instar and 2 in the third instar.

The duration of larval instars of the larvae fed on this mixture is given in Table V.

It is interesting to note that on this mixture 14 of the larvae pupated at the third moult, while on the diet of whole-meal flour alone or on the 20% yeast mixture, the larvae pupated at the fourth and the fifth moults and no larvae which had been bred on either of these diets had 3 instars. The sudden occurrence of larvae of 3 instars on this mixture (10% yeast) raised the question, what factor was responsible for these variations?

In order to find out whether the number of instars is determined by genetical constitution or by external conditions such as food, the following experiment was set up.

The male and female adults which had 3 larval instars in the previous experiment were allowed to mate and the eggs obtained were incubated at 30° C., and 75% R.H. Forty newly hatched larvae were used and reared singly on the same mixture (10% yeast mixture) and kept under the same conditions. For purposes of comparison the present experiment is hereafter referred to as (B_1) as the former experiment was referred to as (B).

In this experiment the number of larvae which pupated at the third moult was increased to 27 as compared with 14 larvae of the same number of instars which occurred at Experiment B. Not only the number of the larvae of 3 instars was increased but also 5 of the larvae had five moults, a number which did not appear at all in Experiment B. Larvae of 4 moults occurred also in Experiment B_1 but the number of these was decreased to 7 as compared with 22 larvae of the same number of instars which occurred in Experiment B. The length of larval life of larvae of 3 instars of Experiment B_1 was slightly shorter than those larvae of 3 instars of Experiment B, the averages being 29.8 and 31.1 days respectively. The length of life of the larvae of 4 instars of Experiments B or B_1 did not differ significantly, the averages being 36.1 and 35.7 days respectively. The larvae which pupated at the fifth moult (Experiment B_1) required an average of 43.9 days to complete their larval life.

In reviewing the above results, the writer suggests that each larva probably had its own specific rate of growth, determined largely by its genetic constitution, but subjected to some variation through the influence of the environment which probably might produce similar if less marked effect in changing the course set by heredity. For this reason the number of moults was not a good criterion for comparing the influence of the various diets with each other.

C. Growth on a diet of 20 % yeast mixture

Forty larvae were reared on this mixture. Further additional yeast proved more satisfactory for the growth of larvae. With this mixture the larvae grew more rapidly than those fed on either whole-meal flour alone or whole-meal flour added to 10 % yeast, pupation of larvae of 4 instars occurred on the thirtieth day and finished on the thirty-ninth day, with an average larval life of 32.9 days as compared with 36.1 and 39.2 days required by the larvae of the same number of instars which fed on 10 % yeast mixture and whole-meal flour alone respectively. The average length of life of the larvae of 5 instars was 42 days as compared with 45 days, the average larval life of the same number of instars which fed on whole-meal flour alone. Pupation took place at the fourth moult (32 larvae) and the fifth (6 larvae) moults. Thirty-eight larvae reached pupation and all these emerged as normal adults, representing 95 % of the total. Very low mortality occurred on this mixture, only 2 larvae out of 40 died during the first instar. The duration of the larval instars on this mixture is given in Table VI.

TABLE VI

The duration of each larval instar and the length of larval stage, fed on a diet of 20 % yeast mixture, and kept at 30° C. and 75 % R. H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	First	Second	Third	Fourth	Fifth	
			Larvae of 4 instars			
Range ..	6-8	4-8	5-7	12-18	—	30-39
Mean...	7	5.8	6.3	13.8	—	32.9
			Larvae of 5 instars			
Range ..	6-8	4-9	6-8	8-9	11-17	36-49
Mean...	7	7.3	6.7	8.3	12.7	42

Comparing the duration of each instar of the larvae of 4 instars given in Table VI, with those of the same number of instars (Table V) which fed on 10 % yeast mixture, that of the first and the last larval instar was in both cases similar, while the second and the third instars of the larvae fed on 20 % yeast mixture had a shorter developmental period than the second and the third instars reared on 10 % yeast mixture.

In the case of larvae which fed on whole-meal flour alone, the average length of life of the first two instars of the larvae of either 4 or 5 instars

(Table IV) was longer than the first two instars of the larvae of 4 and 5 instars which were reared on 20 % yeast mixture, but there was no significant variation in the length of life of the later stages.

D. Growth on a diet of yeast alone

Forty larvae were fed on this diet which was previously proved insufficient and unsatisfactory for growth. The rate of development was noticeably retarded; the first pupation occurred on the fortieth day (for larvae of 4 instars) and the fifty-third day (for larvae of 5 instars) and the last on the fiftieth and sixty-ninth day respectively. The average larval life (4 instars) was 46.2 days as compared with 39.2 on whole-meal flour alone. The length of life of the larvae of 5 instars on yeast alone was considerably longer than that of similar larvae on the flour alone, the averages being 57.8 and 45 days respectively. One larva only had 6 instars with a larval life of 75 days. Pupation took place at the fourth (8 larvae), the fifth (12 larvae) and the sixth (one larva) moults. Twenty-four larvae reached pupation and twenty-one of these emerged as normal adults, representing 52.5 % of

TABLE VII

The duration of each larval instar and the length of larval stage, fed on a diet of yeast alone, and kept at 30° C. and 75 % R. H.

(40 larvae used)

	DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
	First	Second	Third	Fourth	Fifth	
			Larvae of 4 instars			
Range ..	7-9	8-11	7-9	16-22	—	40-50
Mean...	8	10	8	20.2	—	46.2
			Larvae of 5 instars			
Range ..	7-9	9-12	7-10	9-15	14-24	53-69
Mean...	8.2	11	8.2	11.2	18.2	57.8

the total as compared with 85 % of the larvae fed on whole-meal flour alone. Mortality on the diet of yeast alone was very high, 47.5 % of the larvae died or failed to reach adult stage. The larvae died as follows : 9 during the first instar, 4 during the fourth instar, 3 during the fifth instar and 3 pupae died before transforming into the adult stage.

The duration of the instars of larvae fed on yeast alone is shown in Table VII.

A summary of the data on the effect of yeast upon the development of *Stegobium* larvae which were obtained at 25° C., and 30° C. with 75% R. H. is given in Table VIII, which shows the average time to pupation in days (for the larvae of 4 and 5 instars), the number of larvae pupated and the number of adults emerged.

The data in Table VIII, show clearly that the addition of yeast to a diet of whole-meal flour both accelerates the development of larvae and increases survival. It will be seen from Table VIII, that the number of days required for the pupal stage to be reached decreased slightly up to the

TABLE VIII

Summary of results of rearing larvae of Stegobium paniceum *on various diet mixtures, at 25° C. and 30° C., with 75 % R.H.*

(40 larvae used for each diet)

DIETS	AVERAGE TIME TO PUPATION IN DAYS				LARVAE COMPLETED ADULT STAGE AT 25 °C.		LARVAE COMPLETED ADULT STAGE AT 30 °C.	
	LARVAE OF 4 INSTARS		LARVAE OF 5 INSTARS					
	25 °C	30 °C	25 °C	30 °C	No.	%	No.	%
Whole-meal flour..	44.4	39.2	49.5	45	35	87.5	34	85
Whole-meal flour + 10 % yeast.	42.6	36.1	46.9	(1)	37	92.5	36	90
Whole-meal flour + 20 % yeast.	39.5	32.9	45.5	42	39	97.5	38	95
All yeast	83.5	46.2	99.3	57.8	23	57.5	21	52.5

(1) No larvae of 5 instars occured on this mixture : only larvae of three and four instars obtained.

value for 10% and 20% yeast mixtures and then increased rather rapidly in the case of 100 % yeast This seemed to indicate that the addition of yeast supplied some substances which were necessary for the growth of *Stegobium* larvae and which could not be obtained in sufficient quantity from the whole-meal flour alone.

It has been stated and proved experimentally by many authors that yeast contains growth-promoting substances, in particular vitamin B to which the acceleration in growth of larvae is mostly due.

In order to prove whether the growth-promoting properties of yeast were due to the vitamin content or the protein content, the following experiment was designed in which combination of whole-meal flour and 20 % casein was used. The casein was chosen as a protein source, but it should be borne in mind that the protein of the casein is quite different from that

of the yeast. Forty larvae were used and the experiment was conducted at 25° C. and 75 % R.H.

The results show that casein did not permit more rapid growth than the whole-meal flour alone. The length of life of both the larvae fed on the flour alone and the flour with 20% casein added remained the same, an average being 44.4 and 43.3 days (for the larvae of 4 instars) or 49.5 and 49.1 days (for the larvae of 5 instars) respectively. Pupation on the casein mixture took place at the fourth (10 larvae), the fifth (16 larvae) and the sixth (2 larvae) moults. The two larvae which had 6 instars required an average larval life of 73 days to reach pupation. Addition of casein caused more mortality than the whole-meal flour; only 28 larvae out of 40 reached the adult stage as compared with 35 larvae out of 40 fed on whole-meal flour.

The duration of instars of larvae fed on whole-meal flour and whole-meal flour with 20 % casein added to it is given in Table IX, for comparison.

TABLE IX

The duration of each larval instar and the length of larval stage, fed on whole-meal flour and whole-meal flour with 20 % casein, and kept at 25° C. and 75 % R.H.

(40 larvae used in each diet)

DIETS		DURATION OF EACH LARVAL INSTAR IN DAYS					LENGTH OF LARVAL STAGE IN DAYS
		First	Second	Third	Fourth	Fifth	
Larvae of 4 instars							
Whole-meal flour ..	Range .	13-16	9 12	6-8	10-14	—	42-48
	Mean..	14.2	11	7.2	12	—	44.4
Whole-meal flour + 20 % casein	Range .	8-11	8-9	8 10	14-18	—	40-45
	Mean..	9.8	8.5	9	16	—	43.3
Larvae of 5 instars							
Whole-meal flour	Range .	13-16	10-12	6-8	6-9	10-11	46-54
	Mean..	14	10.7	6.5	8	10.3	49.5
Whole-meal flour + 20 % casein	Range .	8-12	7-11	7-9	10-12	10-15	47-53
	Mean..	10	8.5	7.7	10.8	12.1	49.1

It is interesting to note that the duration of the earlier stages of the larvae fed on casein mixture was shorter than that of the earlier stages of the larvae fed on whole-meal flour, while the later stages (on the casein mixture) required longer time to complete their development than the later stages of larvae fed on the flour alone.

Since the growth value of whole-meal flour was considerably improved by the addition of yeast and since no change in the growth rate took place

by adding more protein (casein), it is believed that the growth-promoting properties in the yeast, lies, at least partly in its vitamin content, particularly vitamin B and not in its protein content.

DISCUSSION

From the records at hand, it is clear that *Stegobium* larvae grow normally on a diet of whole-meal flour alone but it should be noted that the rate of growth of the larvae is slightly accelerated by supplementing the flour with 10 % yeast. By increasing the amount of yeast to 20 %, there is a corresponding increase in the final length of the larval life. Unfortunately the time did not permit further study to find out the percentage of yeast required to be added for the rate of growth to reach its optimum. The most probable explanation of these results seems to be that, the yeast supplies some substances which are necessary for the larvae and which cannot be obtained by them from protein or carbohydrate. It is quite possible that the addition of yeast supplies more vitamin B which has been proved to be necessary for growth but no attempt has been made to determine which members of the B complex are required, but the need for such vitamin is comparable with results already obtained for *Drosophila* (North-rop, 1917, and Bacot and Harden, 1922), *Tribolium confusum* (Sweetman and Palmer, 1928, and Street and Palmer, 1935), *Ephestia kuehniella* (Richardson, 1926), and *Dermestes vulpinus* (Gay, 1938).

The addition of casein to the whole-meal flour as a source of protein seems to have no effect on the growth rate of the larvae and the length of larval life remains the same as that of the larvae which fed on flour alone. It seems also that excess protein causes greater mortality. The shortening of larval life is obtained by the addition of yeast. This suggests the necessity of vitamins rather than protein.

The effect of rearing *Stegobium* larvae on yeast alone is to lengthen the larval life and to increase mortality. The following analysis of the yeast used in this study was quoted from Gay (1938) who used the same kind of yeast. The yeast contains, fat 3.4 %, ash 11.1 %, chloride (as NaCL) 0.22 %, total nitrogen 7.1 % (i.e. maximum possible protein 44.4 %).

Van t'Hoog (1935, and 1936), working on *Drosophila*, found a need for fat-soluble factor subsequently proved to be a sterol. He tested the potency of various sterols and found chloresterol and ergosterol to be the most active. Hopkins and Krause (1937) proved that the ergosterol is present in the fact of yeast. Gay (1938) reared larvae of *Dermestes vulpinus* on yeast and salt mixture diet. He stated that the failure in rearing the larvae of *Dermestes* on this mixture diet was due to either such sterol

(ergosterol) being present in insufficient amount in the fat of the yeast or that during the preparation of the dried yeast it is rendered inactive.

The high mortality and the lengthening of larval life of *Stegobium* on the diet, of yeast alone, found by the writer is probably partly due to the same cause as that found by Gay (1938) in his work on *Desmestes vulpinus* but this requires confirmation.

ACKNOWLEDGMENTS

I take the opportunity to tender my gratitude and thanks to Dr. O. W. Richards of the Imperial College, London University, for his valuable advice and criticisms.

I would like to thank also Dr. G. Fraenkel for advice on various physiological matters and to Miss M. B. Hyde for help in obtaining the literature.

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The chemoattraction of food constituents to insects

I. CHEMOATTRACTION OF FOODS TO COCKROACHES

(with 3 Text-Figures)

by E. A. Eisa and A. A. Soliman,
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INTRODUCTION

Cockroaches are well known for their omnivorous habits. They consume every type of food and play an important role in the dissemination of many serious human diseases. For such reasons many authors have been challenged to study the cockroaches and the cockroach problem from various points of view.

Trials are always made to get rid of these insects through various control methods, most particularly via the use of chemical insecticides. Chemical control means, however, are always feared when applied in houses and similar places because of the different toxicity hazards that go along with them.

The destruction of these insects by collecting and killing them in traps will be the ideal method for the use in such places because the insects, thus captured, will have no chance to come out and contaminate food materials.

Although several authors have used many types of olfactometres based on studying the attractive nature of various foods to different insects yet, none of these workers has designed any that might be used as a trap in the mean time.

The attraction of insects to food materials contained in olfactometres of various forms has been studied by a considerable number of authors. Methods applied and food materials used varied in each case. E i s a (1951a) studied the selective power of some food types to cockroaches and found that diets rich in sugars were more attractive to the insects than those

rich in either proteins or fats. In these experiments carbohydrates, proteins and fats were not used independently, but as they exist in natural food diets.

The aim of the present work was to design a trap-olfactometre for cockroaches and to study the attractive powers of separate food elements to these insects.

Apparatus

Various types of olfactometres employed in similar cases by authors elsewhere were studied. Those designed by Barrow (1907), Eagleson (1939), Ditman and others (1941), and several others, were found all unsuitable for the purpose of the present investigation because each was constructed to be used for a particular insect other than cockroaches. The apparatus used by Eisa (1951b) as a cockroaches' olfactometre was considered also imperfect for the following reasons : (1) it did not serve as a trap; (2) the choice of the insects to the type of food they prefer was not completely free.

This made the present authors design an olfactometre which they think most suitable for the purpose of this investigation. The apparatus they constructed is mainly composed of a glass tube of about 60 cms. length and 5 cms. diameter (Fig. 1).

At each end of the tube a muslin funnel is fitted. The narrow opening of the funnel, being directed inwards, acts as a valve in such a manner as to prevent the insects, once captured, from getting out and thus gives the tube the nature of a trap.

A small petri-dish containing the food substance under investigation was introduced at the middle of the tube just at the beginning of the experiment.

For the ease of work in the present experiments glass tubes were used, but for the use in houses and similar places tin tubes, built on the same principle are recommended. A model for a trap of this type with a sliding door, for the introduction of food, constructed by the authors was tested and found very satisfactory (Fig. 2).

Methods and techniques

In the present experiments a set of the described tubes was placed in a glass insect-proof cage of about 250 cubic feet, with two wire-gauze doors as shown in Figure 3.

A lot of about one hundred insects, previously starved for twenty-four hours, was introduced within the cage before the beginning of each test. A five-gram sample of the food used, mixed with one half cubic centimetre of a 10 % solution of mercuric chloride (Hg C12), was introduced in each

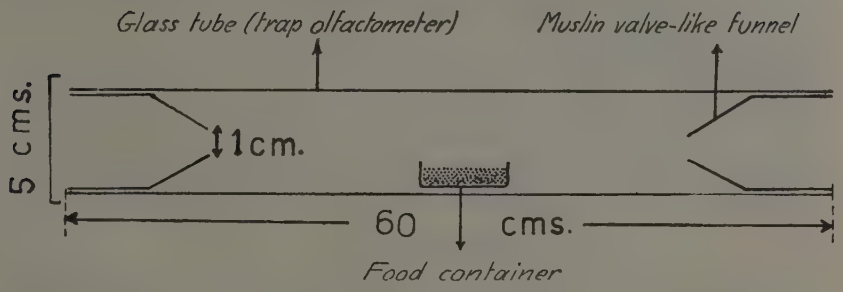

Fig. 1: A diagram of a trap-olfactometre.

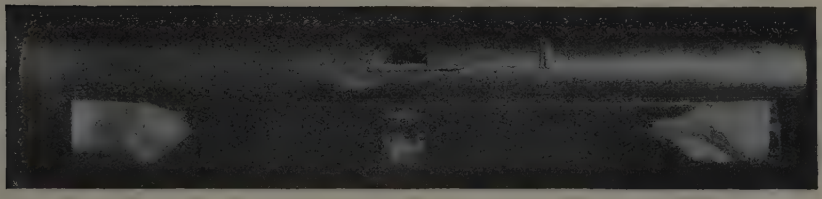

Fig. 2: The tin trap, with one of the glass tubes.

Fig. 3: The insect-proof cage used during the study.

tube. Simultaneously control tubes containing only the poison were also used. The number of cockroaches trapped in each tube was recorded after 24 and 48 hours periods.

The chemoattractive power of different foods was studied in the following steps : (1) variation between mono- , di- , and polysaccharides; (2) variation between animal and plant sugars; (3) variation between animal and plant fats; (4) variation between animal and plant proteins; and (5) variation between carbohydrates, proteins and fats in general.

Experimental results

(1) Glucose, sucrose, maltose and starch were tested. Their attractive powers varied according to the ratio of 5 : 1 : 1 : 1 for maltose and the rest of them respectively.

(2) The attractive powers of both lactose, and sucrose when compared were found the same.

(3) Animal fat and plant oil were compared. More insects were attracted to animal fat than to the oil bearing the ratio of 2 : 1.

(4) This part was studied using gelatin, casein, pepsin, and soybean. The difference in their action according to their successive arrangement is represented by the ratio of 1 : 1 : 35 : 1. Pepsin showed a remarkable attracting power and continued to do so on repeated experiments where tubes were randomized.

(5) The elements compared here were those which proved to be of the highest attractive powers among the various groups. Pepsin, maltose and animal fat were tested. Their attraction to cockroaches varied according to the ratio of 20 : 3 : 2 respectively.

Discussion and conclusions

In the present investigation the control tubes containing mercuric chloride alone attracted no cockroaches. Therefore the addition of this poison in each case did not affect the results to any degree and was not accounted for in the results since it was added in each case. However the presence of this material helped to kill the trapped insects. The cockroaches, thus killed, remained there until they were removed from the trap. This makes the trap designed here very efficient when used in houses and similar places for controlling cockroaches.

The attraction of the insects to foods in the present study varied according to the nature of the food elements used. Experimental results obtained indicate that not only the three main food groups, namely fats, proteins and carbohydrates, vary in their attractive powers, but also members of each of these groups possess a great variation, in this respect, among themselves.

Among carbohydrates, maltose was found superior to other disaccharides as well as to monosaccharides and polysaccharides in their attraction to cockroaches. This variation is probably due to differences in the chemical nature, molecular structure, reducing power and ability of fermentation.

Proteins of both plant and animal origin proved to have the same attraction to cockroaches, with the exception of pepsin, which no matter how randomized were the tubes, was superior to all the rest of the proteins used. This superiority of pepsin may be attributed to the nature of amino acids in which it is richer than other proteins or else due to the way in which they are arranged.

It is of interest to study the effect of these different amino acids before giving a clear explanation for the pronounced action of pepsin. Work along this line is in progress.

The present study also shows that plant oils are less attractive than those of animal origin, probably due to the lack of certain vitamins in the former.

The fact that pepsin was found more attractive than both maltose and animal fat should not lead to the conclusion that proteins are more attractive to cockroaches than both carbohydrates and fats. This is because when a protein other than pepsin, casein for example was compared in one of the experiments with glucose and fat, the carbohydrate attracted more insects than the others. The ratio between the attractive powers of glucose and casein was found to be a 14 : 1 ratio for the carbohydrate and protein respectively.

This makes the authors conclude that, in general, carbohydrates are more attractive to cockroaches than either proteins or fats.

The conclusions arrived at here, however, cannot be generalised quite safely unless many more food elements and various element combinations are studied.

The results reached in the present work are on the other hand enough to state that :

(1) The tubes used in the present study are very efficient and can be used successfully as olfactometre-traps by which cockroaches can be collected and killed.

(2) The addition of poisoned baits in the traps makes the process of cockroaches control easy and safe to handle. The poison being contained within the tubes, unexposed, leaves no chance for poisoning of humans or domestic animals.

(3) No food except that in the traps should be left available to cockroaches in the places where they are to be controlled.

(4) The food used in the traps should be rich in carbohydrates or mixed wtih pepsin.

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Morphology of the adult *Tribolium confusum* Duv. and its differentiation from *Tribolium (Stene) castaneum* Herbst.

[Coleoptera : Tenebrionidae]

(with 79 Text-Figures)

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CONTENTS

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I. INTRODUCTION

The most dominant and abundant beetles of the genus *Tribolium* in Egypt are the confused flour beetle, *Tribolium confusum* Duv., which is actually considered as belonging to the subgenus Stene (see Coleopterorum Catalogus Junk-Schenkling, pars 28, 1911) and the rust-red flour beetle, *Tribolium castaneum* Herbst, 1798 (=*ferrugineum* Herbst, 1797 ; *testaceum*

F., 1798; and *rubens* Cast., 1840) as stated in P. Lepesme : Les Coléoptères des denrées alimentaires et des produits industriels entreposés (*Encyclopédie entomologique*, XXII, Paul Lechevalier éditeur, Paris, 1944); the latter, according to Willcocks (1909 and 1925) is more common. These beetles are of considerable economic importance. They are found all over the world infesting flour and many other prepared and stored products, causing serious loss and considerable damage.

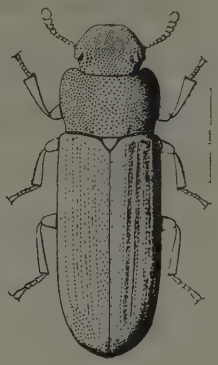


Fig. 1 : *Tribolium confusum* Duv., male.

In Egypt, Willcocks (1925) records that they are troublesome in mills, granaries and stables. Heavy infestation may affect the colour, smell, taste and flavour of the substances invaded.

Attracted by both the economic importance and the general characteristics of these beetles, many investigators have used them as material for their experiments. « They are cosmopolitan, easily obtainable and have a moderately short life-cycle. Both the adults and the immature forms are readily recoverable from the medium for study by a simple technique as they spend their entire life-history in various pulverized grains such as flour » (Park, 1934).

The biology, physiology and control of these beetles have received much attention and a good amount of literature could be procured dealing with these subjects. Regarding their morphology no detailed study seems to have been attempted and it is the aim of the present paper to fill up this gap. A detailed morphology of the confused flour beetle will be discussed and its *sex differentiation in the adult stage*, not known hitherto, will be illustrated. As the rust-red flour beetle, *Tribolium castaneum* Herbst, is very similar to the confused flour beetle, *Tribolium confusum* Duv., a comparative study will be attempted to deal with the external and the internal differentiating characters of these two species.

II. MORPHOLOGY OF TRIBOLIUM CONFUSUM DUV.

A. Name and colour

The « confused flour beetle » is the popular name for *Tribolium confusum* Duv. (Fig. 1). Good (1936) states that Jacquelin du Val (1868) had suggested this name because this insect was until then confused with its closely allied species *Tribolium castaneum* Herbst.

The general colour of the insect is reddish-brown. The metathoracic tergum and most of the abdominal tergites are paler, and are concealed underneath the elytra. A small posterior portion of the seventh or the last apparent abdominal tergite may appear paler than the rest of the body.

B. The head and its appendages

1. Head capsule

The head of the confused flour beetle is of the prognathous type. The dorsal aspect (Fig. 2) is nearly square. The largest width lies between the genae (*Ge*).

The head is pressed dorso-ventrally (Fig. 4) especially anteriorly. Its component sclerites are fused and consequently the usual sutures are obliterated. The anterior portions of the epicranial arms (Figs. 2, 3, and 5, *ea*) are the only remnants of the epicranial suture. These are slightly seen from the dorsal aspect running between the adjacent pits. They could be clearly detected from the ventral aspect (Fig. 5, *ea*) after the removal of the mandibles. Each epicranial arm (Fig. 3, *ea*) extends from the lateral margin of the head and ends at an internal process (*Proc*) serving for the dorsal articulation of the mandibles. Immediately behind this process, the anterior tentorial pit (*at*) is located and appears only from the internal side. The remnant of the epicranial arm does not extend to this pit and it separates the gena from the postclypeus.

The epistomal suture which separates the frons from the clypeus, is marked internally (Fig. 3, *es*, and Fig. 5, *ER*) as a very slight ridge arising from the inner ends of the articulating processes of the mandibles (Fig. 3, *Proc*) and arching strongly anteriorly. It is marked externally (Fig. 2, *EG*) as a slight groove. The frons, consequently, extends anteriorly allowing for the formation of two lateral postclypeal lobes (*Pacl*).

The clypeus is divisible into two parts; the postclypeus (Figs. 2, 3 and 5, *Pacl* + *Pclp*) and the anteclypeus (Figs. 3, and 5 *Aclp*). The former, owing to the anterior extention of the frons (*Fr*), consists of two lateral semi-triangular lobes, the paraclypeal regions (Figs. 2, 3, and 5, *Pacl*) of Crampton (1921), and of an anterior band-like small area (*Pclp*) located along the anterior margin of the head capsule and differentiated by the

absence of the common pits externally. Each paraclypeal region covers the dorsal surface of the corresponding mandible which is entirely concealed when at rest. It is separated from the gena (*Ge*) by the remnant of the epicranial arm (*ea*). The crescentic projection (Fig. 3, *Proc*) serving for the dorsal articulation of the mandible, lies internally at its inner angle. This process is heavily sclerotized and is slightly inclined ventro-laterally. Its outer portion is in close contact with the ridged antennal sclerite (*ASc*).

The ante-clypeus (Figs. 3, and 5, *Aclp*) is a small membrane connecting the labrum (Fig. 4, *Lm*) to the head capsule. It cannot be seen from the dorsal aspect as its connection occurs ventral to the postclypeus.

There are two shallow transverse grooves (Figs. 2 and 4), occurring one behind the other in the dorsal wall of the head capsule. The anterior one (*ATG*) is located in front of the dorsal lobes of the compound eyes (*Ed*) while the posterior one (*PTG*) is located behind them. Owing to the absence of the occiptial suture, the median epicranial suture and the posterior portions of the epicranial arms, the sclerites representing the frons, the parietals (vertex) and the occiput are all fused. But these could be approximately identified by the presence of the remnant of the epicranial arms (Figs. 2, 3, and 5, *ea*), the anterior tentorial pits (Fig. 3, *at*) and the two transverse grooves (Figs. 2 and 4, *ATG*, *PTG*), as will be presently discussed.

The imaginal extensions of the remnant of the epicranial arms — when they are not completely developed — meet on the meson and mark, according to Stickney (1923), the frons from the vertex or preferably the parietals (Crampton, 1921). In the confused flour beetle, this imaginal meeting-point occurs at or somewhat behind the anterior transverse groove (Fig. 2, *ATG*). This means that the posterior limit of the frons (*Fr*) lies at or near this groove, while the region behind this groove is mainly the parietals (*Prtl*). Thus the frons can be approximately represented by the slightly convex area limited posteriorly by the anterior transvese groove, while the external epistomal groove (*EG*) limits it both laterally and anteriorly.

In the confused flour beetle, the portion of the head behind the posterior transverse groove (*PTG*) is retracted into the prothorax. This groove is clearly detected dorsally and laterally but is not so conspicuous ventrally. It approximately takes the course of the hypothetical occipital suture proposed by Stickney. According to this investigator and also to Crampton (1921), the posterior transverse groove differentiates (from the dorsal aspect) the parietals (*Prtl*) anteriorly from the occiput (*Oc*) posteriorly while the postgenae (Fig. 5, *Pge*) lie behind and between its ventral extentions (*G*). Consequently, the parietals occupy the slightly convex area between the two transverse grooves while the occiput (Fig. 2, *Oc*) occupies a broad dorsal area behind the posterior transverse groove. The occiput continues laterally with the ventral postgenae (Fig. 4) as the differentiating sutures are lacking. Both

the occiput and the postgenae occupy the major posterior region of the cranium.

The area located in front of the dosal lobe of the compound eye is the gena (Figs. 2, 3, and 5, *Ge*). This is broad owing to its lateral extention

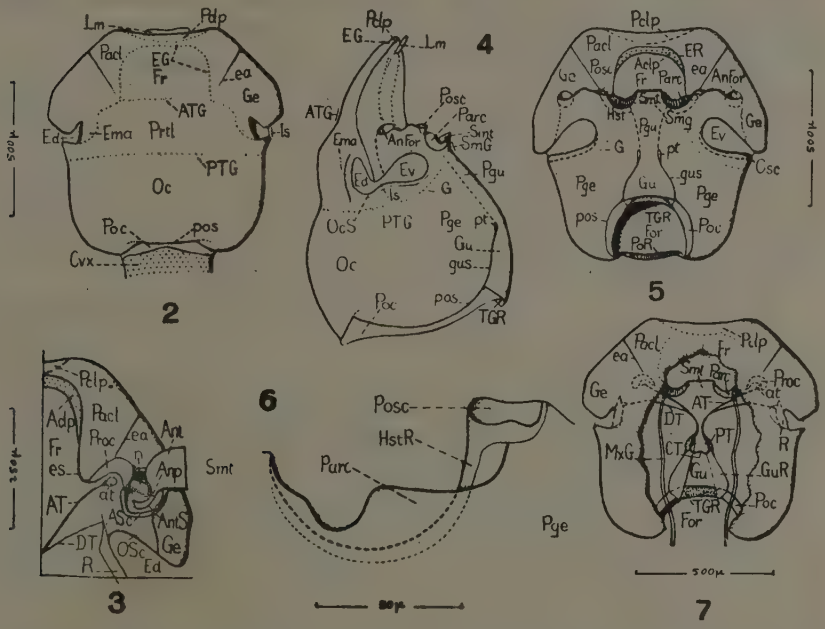


Fig. 2: The head capsule, dorsal view. — Fig. 3: The antero-lateral region of the dorsal wall of the head capsule, ventral view. — Fig. 4: The head capsule, lateral view (much enlarged). — Fig. 5: The head capsule, ventral view. — Fig. 6: The anterior region of the postgena, internal view. — Fig. 7: The head capsule with the median region of the dorsal wall removed to show the tentorium and the maxillary glands.

(*Aclp*, anteclypeus or preclypeus; *AnFor*, antennal foramen; *Anp*, antennal process; *Ant*, antenna; *AntS*, antennal socket; *ASc*, antennal sclerite; *AT*, anterior tentorial arm; *at*, anterior tentorial pit; *ATG*, anterior transverse groove; *CT*, tentorial body; *Cvx*, cervical membrane; *Dt*, dorsal tentorial arm; *ea*, epicranial arm; *Ed*, dorsal lobe of the compound eye; *EG*, epistomal groove; *Ema*, emargination of the eye; *es*, epistomal suture (*ER* in Fig. 5); *Ev*, ventral lobe of the compound eye; *For*, occipital foramen; *Fr*, frons; *G*, ventral extention of the posterior transverse groove; *Ge*, gena; *Gu*, gula; *GuR*, longitudinal gular ridge; *Gus*, gular suture; *Hst*, hypostoma; *HstR*, hypostomal ridge; *Is*, constricted portion of the compound eye, connecting its dorsal and ventral lobes; *Lm*, labrum; *n*, antennal pivot (antennifer); *MxG*, maxillary gland; *Oc*, occiput; *OSc*, ocular sclerite (*OcS* in Fig. 4, and *Osc* in Fig. 5); *Pacl*, paraclypeus; *Parc*, postgenal process for the articulation of the maxilla; *Pclp*, anterior median region of the postclypeus; *Pge*, postgena; *Pgu*, pregula; *Poc*, postocciput; *PoR*, postoccipital ridge; *pos*, postoccipital suture; *Posc*, postgenal cavity for ventral articulation of the mandible; *Proc*, process for dorsal articulation of the mandible; *Prtl*, parietals; *PT*, posterior tentorial arm; *pt*, posterior tentorial pit; *PTG*, posterior transverse groove; *R*, ridge; *SmG*, groove between the submentum and the pregula; *Smt*, submentum; *TGR*, transverse gular ridge).

and is separated from the paraclypeal region (*Pacl*) by the remnant of the epicranial arm (*ea*). Its caudal extention emarginates the compound eye (Fig. 4) causing it to be divided into a dorsal (*Ed*) and a ventral (Figs. 4, and 5, *Ev*) lobes. The gena, together with the paraclypeal region, form a thin shelf-like extention along each side of the anterior region of the head capsule. They fall within a level somewhat lower than that of the frons.

The ocular sclerite (Fig. 4, *OcS*) is represented by a very narrow but more sclerotized area surrounding the compound eye. Along the inner margin of the dorsal lobe of the compound eye (Fig. 3, *Ed*), there is an internal prominent ridge (*R*).

The antennal sclerite (Fig. 3, *ASc*) is located on the ventral side of the gena (*Ge*) without any indication of its presence dorsally. It lies in front of the dorsal lobe of the compound eye (*Ed*), lateral to the articulating process for the mandible (*Proc*) and behind the epicranial arm (*ea*).

The post-occipital suture (Figs. 2, 4, and 5, *pos*) is well developed, occurring on the posterior region of the cranium. It encloses between it and the occipital foramen (Fig. 5, *For*) a marginal narrow rim, the post occiput (Figs. 2, 4, and 5, *Poc*). The latter is less sclerotized, being reduced in area mid-dorsally but broadens somewhat laterally. It is connected posteriorly to the cervical membrane (Fig. 2, *Cvx*). The dorsal portion of the post-occipital suture (Fig. 2, *pos*) arches slightly posteriorly forming internally a strong post-occipital ridge (Fig. 5, *PoR*) while the ventral ends of this suture continue with the gular sutures (Figs. 4, and 5, *gus*) which are actually considered as its anterior extention on the ventral wall of the head capsule (Stickney, 1923, and Snodgrass, 1935).

The occipital foramen (Fig. 5, *For*) is comparatively large. It is not completely circular; the dorsal and ventral margins being more pushed anteriorly, but the former is less so than the latter. Its ventral margin which is the posterior margin of the gula (*Gu*) is ridged forming a transverse gular ridge (Figs. 4, and 5, *TGR*).

As is the case in most Coleoptera, the submentum (Figs. 4, and 5, *Smt*) lies far in advance of the occipital foramen. It is a square sclerite fused with the middle anterior margin of the ventral wall of the cranium. Its posterior limit is marked by a shallow groove (*SmG*).

In generalized insects, the posterior tentorial pits are the land marks for the posterior limit of the submentum. But in the confused flour beetle there is a differentiated sclerite between these pits (Figs 4, and 5, *pt*) and the submentum (*Smt*), the so-called « pregula » (*Pgu*) of Crampton (1921).

The gula (Figs. 4, and 5, *Gu*) is a distinct sclerite occupying the middle posterior area of the ventral surface of the cranium. The gular sutures (*gus*)

do not meet anteriorly but extend half the distance to the submentum, ending by the posterior tentorial pit (*pt*). Both the gula (*Gu*) and the pregula (*Pgu*) are devoid of the common pits which are present in the adjacent postgenae (*Pge*). The gular sutures are ridged internally (Fig. 7, *GuR*) as does the posterior gular margin (Figs. 4, 5, and 7, *TGR*).

The postgena (Figs. 4, and 5, *Pge*) occupies the region lateral to the gula and the pregula and is located posterior and mesal to the ventral extensions (*G*) of the posterior transverse groove. Its anterior margin (Figs. 4, 5, and 6) is more sclerotised, presenting two articular surfaces, the inner of which is represented by a strong ridge (*Parc*) receiving the maxillary cardo, while the outer one (*Posc*) is a socket to which the mandible articulates ventrally. Lateral to this socket, the anterior margin of the ventral wall of the cranium extends laterally ending at the outer portion of the antennal sclerite (Figs. 4, and 5, *ASc*), forming with the latter a foramen (*AnFor*) which receives the antennal scape.

2. Tentorium

The tentorium (Fig. 7) consists of the anterior, the dorsal and the posterior tentorial arms together with the tentorial body.

The anterior tentorial arm (Figs. 3, and 7, *AT*) arises from the anterior tentorial pit (*at*) which lies immediately behind the articulating process (*Proc*) of the mandible and which appears only from the internal side. It extends postero-mesally (Fig. 7, *AT*) as a fine sclerotized rod enlarging somewhat posteriorly where it becomes almost in contact with the corresponding one of the other side without being fused. It then diverges posteriorly and finally fuses with the corresponding posterior tentorial arm (*PT*).

The posterior tentorial arm (*PT*) arises from the posterior tentorial pit (Figs. 4, and 5, *pt*) which is rather a short and narrow longitudinal groove located at the anterior end of the gular suture. Consequently, the posterior tentorial arm (Fig. 7, *PT*) has a broad base, but tapers dorsally and is directed somewhat anteriorly towards the inside, fusing distally with the posterior end of the anterior tentorial arm. It is comparatively much shorter but broader than the latter. The gular suture forms internally a gular ridge (*GuR*) which is continuous posteriorly with the posterior tentorial arm but less sclerotized than the latter. The gular ridges are directed inwards, but do not meet dorsally, and are connected posteriorly with the lateral ends of the transverse gular ridge (*TGR*) located at the gular posterior margin internally.

At the fusion-point of the anterior and the posterior tentorial arms, the tentorial body (*CT*) arises as an incomplete ring-like structure directed postero-dorsally. Its posterior portion arches slightly anteriorly. The whole tentorial body forms with the hind portions of the anterior tentorial arms a flask-like structure.

From the front portion of the anterior tentorial arm, a branch arises representing the dorsal tentorial arm (*DT*). This is a fine rod ending internally at the mesal internal ridge of the eye, without any external indication of a dorsal tentorial pit. At the branching-point, the dorsal tentorial arm is similar in size to the anterior tentorial arm but thins out as it continues distally.

3. Mouth-parts

The mouth-parts of the confused flour beetle are of the chewing type. They consist of :

(A) The labrum (Fig. 8), which is three times as broad as long. The median anterior region of the dorsal wall of the head capsule overlaps the major portion of the labrum (Fig. 1, and Figs. 2, and 4, *Lm*) which is connected to the former by the small membranous anteclypeus. At this connection the tormae (Fig. 8, *Tor*) arise in the form of two transverse sclerotized rods well identified at their inner portions but fuse laterally with the rods (Fig. 15, *EphRO*) flanking the epipharyngeal wall.

The anterior margin of the labrum (Fig. 8) is slightly concave while its sides are round. It is fringed with stout setae which are long medially but become gradually shorter laterally. In addition to these, short setae are also distributed all over the dorsal surface of the labrum. When at repose, the labrum is directed antero-ventrally, closing partly the preoral cavity anteriorly.

(B) The mandibles which, when at rest, are concealed under the paraclypeal regions. Each mandible (Figs. 9, 10, 11, and 12) is a thick, strong and heavily sclerotized structure, the top of which is inclined inwards. Its dorsal (Figs. 9, and 10), ventral (Fig. 11) and outer (Fig. 12) surfaces reach the distal end of the organ while the inner surface (Fig. 11, *MolS*) extends only a short distance from the base representing the molar area. The outer surface possesses short dispersed setae.

The entire inner side of the mandible has three masticatory parts. The distal part represents the inner side of the incisor lobe (Figs. 9, 10, and 11, *Inc*) and shows a case of asymmetry between the right and the left mandibles. That of the right mandible (Figs. 9, and 11) bears three teeth while that of the left (Fig. 10) bears only two. The distal tooth (Figs. 9, 10, 11, and 12, *Disd*) is more pointed than the middle one (*Midd*) which projects from the ventral surface inwards. A third proximal tooth (Figs. 9, and 11, *Prod*) is displayed only by the incisor lobe of the right mandible where it is rather blunt but prominent. The posterior inner region of the more sclerotized incisor lobe projects more conspicuously in the left than in the right mandible.

The median part of the inner side of the mandible carries a flexible membranous structure, the prostheca (*Pros*) of Imms (1934). This latter has very fine hairs especially near the molar lobe (*Mol*).

The proximal part of the inner side of the mandible represents the more sclerotized molar lobe (*Mol*) which has an inner, triangular and furrowed molar surface (Fig. 11, *MolS*). The molar lobe presents at its base a membranous structure (Figs. 9, and 10, *Subm*), similar but smaller than the prostheca and, likewise, bears very fine hairs.

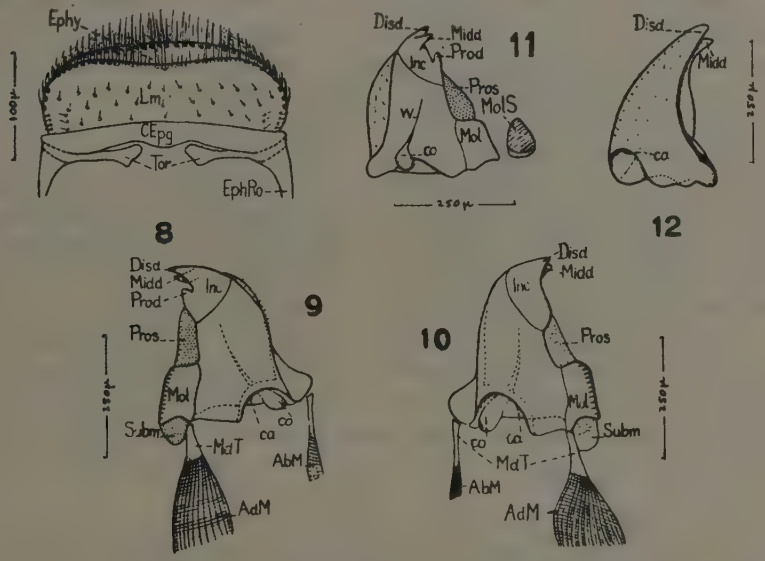


Fig. 8: The labrum with the supporting sclerotized region of the epipharyngeal wall, dorsal view. — Fig. 9: The right mandible, dorsal view. — Fig. 10: The left mandible, dorsal view. — Fig. 11: The right mandible, with the molar surface (*MolS*), inner view. — Fig. 12: The left mandible, lateral (outer) view.

(*AbM*, abductor muscle; *AdM*, adductor muscle; *ca*, cavity for the dorsal articulation of the mandible (gynglymus); *co*, condyle for the ventral articulation of the mandible; *CEpg*, sclerotized area of the epipharyngeal wall; *Disd*, distal tooth of the mandible; *Ephy*, epipharynx; *EphRo*, epipharyngeal rod; *Inc*, incisor lobe; *Lm*, labrum; *MdT*, mandibular tendon; *Midd*, middle tooth of the mandible; *Mol*, molar lobe; *MolS*, molar inner surface; *Prod*, proximal tooth of the mandible; *Pros*, prostheca; *Subm*, submola; *Tor*, torma; *w*, suture).

The mandible has two pivoting points; the ginglymus (Figs. 9, 10, and 12, *ca*) and the condyle (Figs. 9, 10, and 11, *co*). The former is a semicircular fossa serving for dorsal articulation while the latter is a prominent projection serving for ventral articulation of the mandible. An elevated scar (Fig. 11, *w*) arises from the condyle and runs on the ventral surface of the mandible towards the incisor lobe but hardly reaches it. Each mandible is

moved by a large adductor (Figs. 9, and 10, *AdM*) and a smaller abductor (*AbM*) muscles inserted on mandibular tendons (*MdT*).

(C) The maxilla (Fig. 13) which is well developed and is composed of :

(1) The cardo (*Cd*) is a more or less hemispherical single sclerite with a straight anterior limit and with round lateral and proximal sides. It articulates with the ridged anterior semicircular region of the postgena. A foot-like basal process (*Cdp*) of the cardo strengthens this articulation.

(2) The stipes consists of three sclerites of which the ventral one (*Bsst*) is triangular and more sclerotized especially laterally. This sclerite has short setae distributed on its surface. Anterior and inner to the ventral sclerite, there is a longer and fairly sclerotized sclerite of the stipes (*Eust*) which supports the galea distally. It has one stout and long seta on its median region of the ventral surface which is somewhat inclined towards the labium. The inner region of this sclerite (*Eust*) is embraced by the basal portion of the lacinia (*Bslc*). The third sclerite of the stipes is the palpifer (*Plf*) which occupies its outer and dorso-lateral region and supports the maxillary palpus. Disto-laterally, it bears long setae some of which are two times as long as the first segment of the palpus (*1plp*). It is more sclerotized dorsally (its inner limit is dotted in Fig. 13).

(3) The maxillary palpus (*plp*) is four-segmented. The segments are unequal in size and length. The first segment (*1plp*) is less than half the length of the second (*2plp*) which is longer than the third (*3plp*). The fourth segment (*4plp*) is the largest. It has a membranous tip (*Mb*) inclined inwards and bearing some circular and some cone-like structures (*Sen*), possibly sense organs.

(4) The galea is not uniformly sclerotized. Its basal or proximal portion (*Bsga*) is similar in sclerotization and nearly in size to the first palpal segment but is rather crescentic. Its median region (*Miga*) is membranous and is devoid of setae. Its larger distal portion (*Diga*) is fairly sclerotized, carrying, besides the dispersed setae, a distal crown of long setae (*F*).

(5) The lacinia is well developed and is free distally but embracese proximally the inner portion of the inner sclerite of the stipes (*Eust*). It ends distally with an incisor tip provided with two teeth (*d*). The part of the inner margin following these teeth posteriorly, bears stout and curved setae (*L*).

The basal portion of the lacinia (*Bslc*) is more sclerotized. It enlarges considerably, extending on the dorsal surface of the inner sclerite of the stipes (limits of this enlargemenet is dotted in Fig. 13).

(D) The labium of the confused flour beetle which consists of :

(1) The submentum (Figs. 4, and 5, *Smt*) fuses entirely with the ventral wall of the cranium. No distinct suture marks its posterior limit but

there is, instead, a shallow groove (*Smg*) differentiating it from the pregula (*Pgu*). The submentum presents the common pits of which the gula and the pregula are devoid.

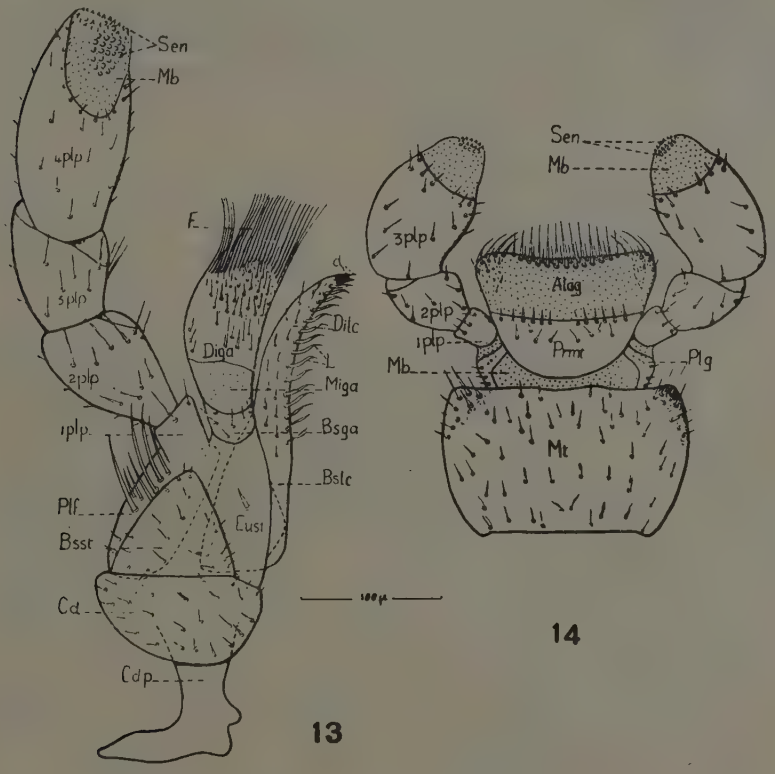


Fig. 13: The maxilla, ventral view. — Fig. 14: The mentum and the prelabium, ventral view.

(*Alag*, fused glossal lobes (alaglossa); *Bsga*, basal sclerite of the galea; *Bslc*, basal sclerite of the lacinia; *Bsst*, basal sclerite of the stipes; *Cd*, cardo. *Cdp*, process of the cardo; *d*, lacinial teeth; *Diga*, distal sclerite of the galea; *Dilc*, distal sclerite of the lacinia; *Eust*, inner sclerite of the stipes; *F*, crown of the galea; *L*, lacinial curved setae; *Mb*, membrane; *Miga*, median sclerite of the galea; *Mt*, mentum; *Plg*, palpiger; *Plf*, palpifer; *plp*, the palpus (Arabic numbers refer to the number of the segments); *Prmt*, prementum; *Sen*, sense organs).

(2) The mentum (Fig. 14, *Mt*) is a large well developed sclerite hinged to the distal margin of the submentum. It is broader than long and is ventrally convex. Its antero-lateral angles are more inclined laterally bearing longer and denser setae than those dispersed on the external surface of the mentum. Its posterior margin is nearly straight and slightly exceeds, on

either side, the anterior margin of the submentum. Though the latter fuses entirely with the cranium, the mentum is movably hinged to it.

(3) The prelabium includes the prementum (*Prmt*), the labial palpi (*plp*) and the terminal lobes representing the glossae and the paraglossae. Though located anterior to the mentum, the prelabium is not hinged directly to its anterior margin owing to the presence of an infolded membrane (Fig. 14, and Fig. 15, *Mb*) connecting the prelabium to the dorsal internal surface of the mentum.

(a) The prementum (Fig. 14, *Prmt*) is represented by a fairly sclerotized plate occupying the proximal region of the prelabium. It is a broad structure with acute disto-lateral angles, a straight anterior limit and round lateral and posterior sides. It has dispersed short setae on its ventral surface especially on its anterior region.

(b) The labial palpi (Fig. 14, and Figs. 15, and 16, *plp*) are situated laterally, each on a membranous area strengthened at the palpal base by the broad distal end of a hypopharyngeal apodeme (*Plg*) representing the palpiger. Dorsally, there is another small and fairly sclerotized sclerite (Figs. 15, and 16, *f*) located at the base of the palpus.

The labial palpus has three segments; the basal one (Fig. 14, *lplp*) is the smallest while the distal (3*plp*) is the largest and possesses a distal membranous area (*Mb*) bearing some round and some cone-like structures (*Sen*), possibly sense organs (Glaser, 1927).

(c) The glossae are combined, forming a single membranous area (*Alag*). Its distal margin is slightly concave and is fringed with long setae shortening gradually laterally. Its disto-lateral regions carry also short setae.

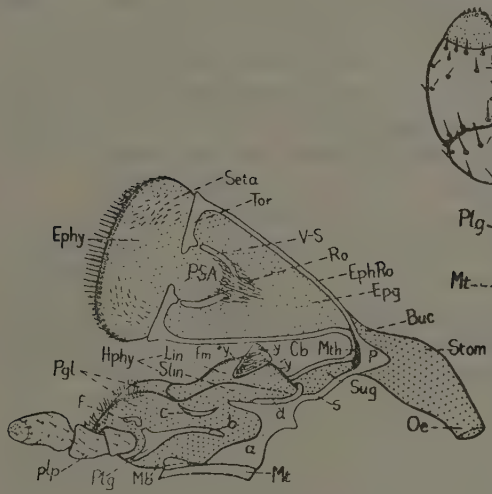
(d) The paraglossae (Figs. 15, and 16, *Pgl*) are represented by two lobes directed towards the inside and are continuous posteriorly with the lateral portions of the hypopharynx (Fig. 15). Their dorsally-directed margins are also fringed with short setae.

4. Preoral cavity

The cavity located between the epipharyngeal and the hypopharyngeal walls in the head is called, by Snodgrass (1935), the « preoral cavity ». He considers the true mouth to be the aperture located at the anterior end of the stomodaeum.

(a) The epipharyngeal wall (Fig. 15) extends from underneath the labrum to the true mouth (*Mth*). The part located underneath the labrum and in front of the tormae (*Tor*) is the epipharynx (*Ephy*). This latter has a convex anterior margin fringed with setae and protruding, together with a small anterior area of the epipharynx, from underneath the labrum (Fig. 8, *Ephy*). Short setae (Fig. 15, *Seta*) are also dispersed on the ventro-lateral regions of the epipharynx.

Behind the tormae, the epipharyngeal wall (*Epg*) continues posteriorly as a membranous structure continuous proximally with the roof of the buccal cavity (*Buc*). It is flanked on either side by a fairly sclerotized apodeme, the epipharyngeal rod (*EphRo*). The latter fuses anteriorly with the lateral parts of the tormae, then it runs posteriorly and finally fuses with a small triangular and fairly sclerotized plate (*p*), located at the side of the buccal cavity.



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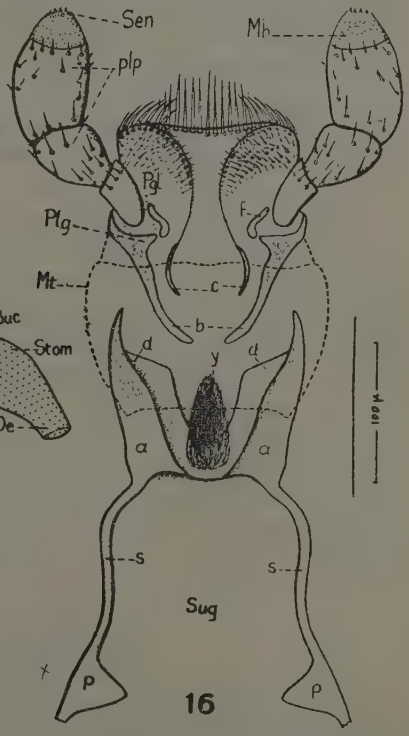

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Fig. 15: The preoral cavity as seen from the left side with the epipharyngeal wall deviated to show its ventral view (much enlarged). — Fig. 16: Skeleton of the hypopharyngeal wall, with the anterior lobes of the prelabium, dorsal view.

(*a*, lateral basal plate of the hypopharynx; *b*, distal outer apodeme of the hypopharynx; *Buc*, wall of the buccal cavity; *c*, distal inner apodeme of the hypopharynx; *Cb*, proximal chamber of the preoral cavity (cibarium); *d*, basal dorsal plate of the hypopharynx; *Epg*, proximal region of the epipharyngeal wall; *f*, plate at the base of the labial palpus; *fm*, distal chamber of the preoral cavity (food meatus); *Hphy*, hypopharynx; *Lin*, lingua; *p*, plate at the side of the buccal cavity; *Pgl*, paraglossa; *PSA*, posterior area of the epipharynx; *Ro*, sclerotized rods; *s*, apodeme along the proximal area of the hypopharyngeal wall; *Seta*, seta on the epipharynx; *Slin*, superlingua; *Stom*, stomodaeum; *Sug*, proximal area of the hypopharyngeal wall; *V-S*, V-shaped structure; *y*, triangular lobe on the dorsal region of the hypopharynx; *y'*, posterior sclerotization on the dorsal surface of the hypopharynx; *y''* anterior sclerotization on the dorsal surface of the hypopharynx).

For other explanation refer to Figures 13 and 14.

The area of the epipharyngeal wall located immediately behind the labrum (Fig. 8, *CEpg*) is fairly sclerotized and is best seen from the dorsal aspect.

The epipharyngeal wall bears ventrally a v-shaped sclerotized structure (Fig. 15, *V-S*), the apex of which is directed posteriorly while the anterior ends of its arms articulate with the inner ends of the tormae (*Tor*). An area of the epipharynx (*PSA*) extends between these arms. Between and on either sides of the caudal portions of the arms, there is a patch of fine sclerotized rods (*Ro*) which more or less conceal the apex of this structure.

(b) The hypopharyngeal wall is proximally membranous (*Sug*) but its major distal region is represented by the hypopharynx (*Hphy*). The proximal membrane (*Sug*) is also flanked on either side by a fairly sclerotized rod (*s*) arising from the basal apodeme (*a*) of the hypopharynx and fuses posteriorly with the plate (*p*) located at the side of the buccal cavity (*Buc*).

The hypopharynx (*Hphy*) is a median lobe representing the distal portion of the hypopharyngeal wall and located entally on the free portion of the labium. It includes :

(1) The lingua (*Lin*), which constitutes the median and major lobe of the hypopharynx, standing as a tongue-like structure in the anterior portion of the preoral cavity. On its dorsal surface near the base, there is a triangular lobe (*y*) constructed of a compact patch of heavily sclerotized rods (Fig. 16, *y*). A very narrow sclerotized longitudinal area (Fig. 15, *''y*) arises from this lobe and extends anteriorly and for a short distance on the dorsal surface of the lingua. A similar but shorter area (*'y*) extends posteriorly and somewhat vertically from this lobe but does not continue on the proximal membranous area (*Sug*).

(2) The superlinguae (*Slin*) are only represented by the lateral portions of the hypopharynx which continue and fuse anteriorly with the paraglossae (*Pgl*).

(3) The skeleton of the hypopharynx is composed of well developed apodemes supporting its base and distal regions.

(a) At the base there is a vertical sclerotized plate (*a*) arising on either side from the basal portion of the lateral margin of the mentum (*Mt*) and extending dorsally to support the basal region of the hypopharynx. It broadens distally and proximally but nrarows medially where it inclines somewhat inwards. Its distal portion prolongs anteriorly along the upper lateral region of the hypopharynx. Its posterior portion forms two angles from the dorsal of which the apodeme (*s*) flanking the proximal area of the hypophrayngeal wall, arises. A horse-shoe and more sclerotized horizontal apodeme (Figs. 15, and 16, *d*) connects the right and the left vertical plates (*a*) from their dorsal margins and forms with them, together with the posterior margin of the mentum, a circular foramen.

(b) The distal apodemes supporting the hypopharynx include two pairs. The former pair (*b*) is larger. Each of its apodemes runs on the lateral wall of the hypopharynx. It extends and broadens anteriorly forming the palpiger (*Plg*) of the labial palpus. The other pair comprises two small crescentic apodemes (*c*) coinciding with the distal end of the hypopharynx.

5. Compound eyes

In the confused flour beetle, the compound eye is double-lobed (Fig. 4), being composed of a small dorsal (Figs. 2, 3, and 4, *Ed*) and a larger ventral (Figs. 4, and 5, *Ev*) lobes. The two lobes are not completely separated but are still connected by a facetted narrow area (Fig. 4, *ls*). The double-lobed condition results from the caudal emargination of the gena (Figs. 2, 4, and 5, *Ge*) which causes the anterior ocular margin to project posteriorly. The posterior ocular margin tends also to project slightly anteriorly.

The two lobes of the compound eye are directed cephalomesad (Fig. 4) though the ventral lobe is less so. The latter is larger and more oval than the dorsal one which appears smaller still owing to the immediate emargination (Figs. 2, and 4, *Ema*) of the parietals. The inner region of the ventral lobe is comparatively much broader.

6. Antennae

The antennal sclerite (Fig. 3, and Fig. 17, *ASc*) is ridged and located ventrally on the gena anterior to the dorsal lobe of the compound eye and lateral to the articulating process of the mandible. A prominent process, the antennal pivot (*n*), arises from the inner side of the antennal sclerite and

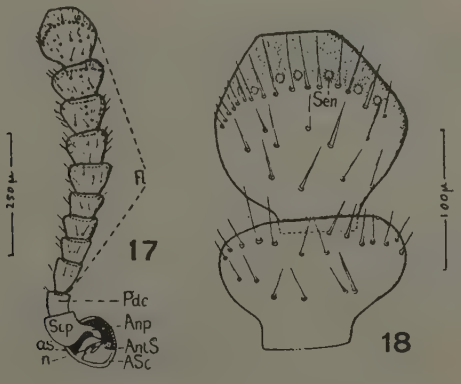


Fig. 17: The antenna and the antennal sclerite, ventral view. — Fig. 18: The two distal antennal segments, ventral view.

(*Anp*, antennal process; *AntS*, antennal socket; *as*, antennal suture; *ASc*, antennal sclerite; *Fl*, flagellum; *n*, antennal pivot; *Pdc*, pedicel; *Scp*, scape; *Sen*, disk-like sense organs).

projects into the antennal socket (*AntS*) supporting the scape (*Scp*) of the antenna. The posterior half portion of both the antennal sclerite and the antennal socket are concealed ventrally by the antero-lateral region of the ventral wall of the cranium (Figs. 4, and 5). The latter forms with the anterior portion of the antennal sclerite a foramen (*AnFor*) which receives the scape of the antenna and is directed antero-ventrally. The outer portion of the antennal sclerite fuses with the antero-lateral limit of the ventral wall of the cranium (Figs. 3, and 4).

The antenna (Fig. 17) is clavate and consists of eleven segments. The scape (*Scp*) is larger than the pedicel (*Pdc*) and is round proximally. A curved tap-like process (*Anp*) arises from the base of the scape and lies in the antennal socket coinciding with the outer portion of the antennal sclerite (*ASc*).

The flagellum (*Fl*) consists of nine segments of which the first (the third segment of the antenna) is somewhat larger than the pedicel and is clearly constricted at the base. The fourth, fifth, sixth and seventh segments of the antenna though equal in length, they gradually increase in size. The eighth, ninth and tenth increase gradually in length and width. The terminal segment is roughly spherical with a constricted clear base and a portion of its distal circumference truncated. The gradual enlargement of the flagellum towards the apex is characteristic.

Sense setae are dispersed all over the antennal segments.

C. The thorax and its appendages

1. Neck or cervix

When the head is fully stretched, a short membranous region, the neck (Fig. 2, *Cvx*), appears. It is entirely membranous without any visible cervical sclerites.

2. Thorax

The thorax of the confused flour beetle includes a large portion of the insect body. It consists of the usual three segments following the head; the prothorax, the mesothorax and the metathorax. The two latter segments are immovably constructed as in the case in most beetles (Crowson, 1938), with their terga pushed more anteriorly than their corresponding pleura and sterna. Unlike the sclerotized annular prothorax, the meso- and the metanotum are more or less connected by membranous areas to their pleura.

a. Prothorax

The prothorax represents the largest thoracic segment and exceeds in size any of the other body segments. It is broader than long and is pressed

somewhat dorso-ventrally (Figs. 19, 21, and 22). Its widest part lies in its anterior region. It is connected anteriorly to the head by the membranous neck and posteriorly to the mesothorax by a well marked intersegmental

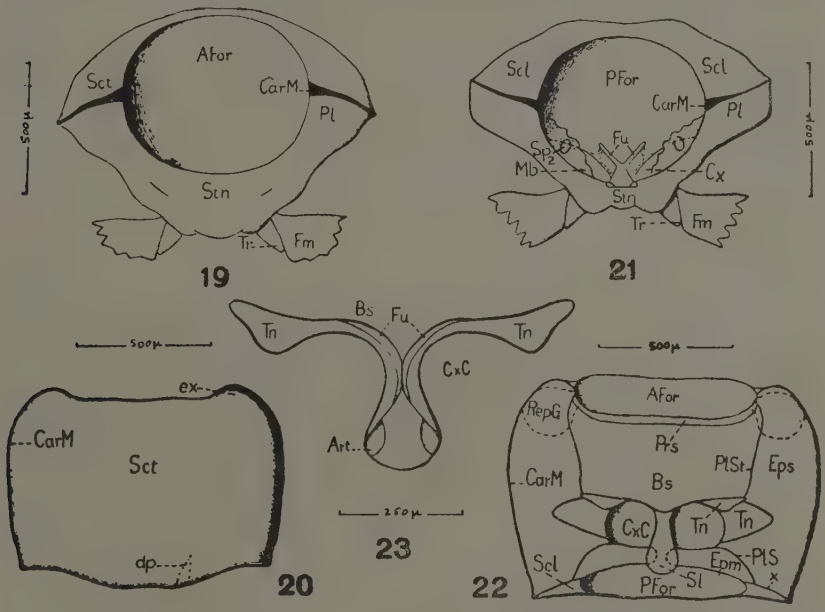


Fig. 19: The prothorax, anterior view. — Fig. 20: The prothorax, dorsal view. — Fig. 21: The prothorax, posterior view. — Fig. 22: The prothorax, ventral view. — Fig. 23: The sternellum and parts of the trochantin, internal view.

(*AFor,* anterior foramen; *Art,* area for the articulation of the epimeron; *Bs,* basisternum; *CarM,* carinated margin; *Cx,* coxa; *CxC,* coxal cavity; *dp,* depression; *Epm,* epimeron; *Eps,* episternum; *ex,* anterior extension of the prothorax; *Fm,* femur; *Fu,* furculum; *Mb,* membrane; *PFor,* posterior foramen; *Pl,* pleuron; *PlS;* pleural suture; *PlSt,* pleurosternal suture; *Prs,* presternum; *RepG,* repugnatorial gland (dotted); *Scl,* scutellum; *Sct,* scutum; Sp_2, mesothoracic spiracle; *Stn,* sternum; *Tn,* trochantin; *Tr,* trochanter; *x,* margin between the pleuron and the scutellum).

membrane to allow it to move freely. Consisting of a sclerotized annular segment, the tergal, pleural and sternal elements of the prothorax are firmly attached without any apparent membranous areas in between. Because the prothorax is somewhat broader in front, its anterior foramen (Fig. 19, *AFor*) is slightly wider than the posterior one (Fig. 21, *PFor*).

The prothorax consists of :

(1) The pronotum which has two sclerites ; the scutum and the scutellum.

(a) The scutum (Fig. 20, *Sct*) is a large plate constituting the entire dorsal surface of the pronotum. It is broader than long with the whole surface more or less convex dorsally. Its antero-lateral angles are round, extending slightly more anteriorly than does the front margin. The lateral margins arch outwards forming distinct carinated limits (Figs. 19, 20, 21, and 22, *CarM*) with the pro-pleura. Their basal portions are, on the reverse, slightly concave forming more or less right angles with the rear margin. The one-third median portion of the latter margin extends somewhat posteriorly than the lateral portions. Two very shallow depressions (Fig. 20, *dp*) (not so clear in some specimens) appear on the posterior region of the scutum, arising at the rear margin, lateral to the mid-dorsal line and extending antero-laterally for a short distance.

(b) The scutellum (Figs. 21, and 22, *Scl*) appears mainly from the posterior aspect. It is reduced in area medially but broadens laterally, occupying the regions on either side of the posterior foramen (Fig. 21, *PFor*), between the scutum dorsally and the pro-pleura ventrally.

(2) The propleura :- Owing to the lateral extention of the pronotum, no part of the propleura could be seen from the dorsal aspect. The pleurosternal suture (Fig. 22, *PlSt*) is distinct separating the sternal from the pleural regions. The pleural suture (*PlS*) is very short and differentiates a much larger episternum (*Eps*) from a smaller epimeron (*Epm*). It extends between the fore coxal cavity (*CxC*) and the inner portion of the margin (*x*) located between the scutellum and the pleuron. It arches somewhat antero-laterally and is slightly ridged internally.

(a) The episternum (Fig. 22, *Eps*) occupies the entire lateral area of the ventral surface of the prothorax. It extends from the anterior foramen antero-laterally to the vertical scutellum posteriorly. As the pleurosternal suture (*PlSt*) extends antero-laterally, the front episternal region narrows gradually anteriorly. The lateral carinated margin (*CarM*) of the prothorax separates the episternum ventrally from the pronotum dorsally. The episternum falls within a level different from that of the epimeron or the sternum.

(b) The epimeron (Fig. 22, *Epm*) is comparatively smaller and slightly more sclerotized than the episternum. It occupies the posterior ventral region of the prothorax. Except for a small median portion of the sternum (the sternellum (*Sl*)) the two epimera extend inwards enclosing the two coxal cavities (*CxC*) posteriorly and forming a band-like rim along the main ventral margin of the posterior foramen (*PFor*). Their extreme inner ends project beneath and articulate with the lateral areas of the median prosternellum (*Sl*). Accordingly, the fore coxal cavities are entire (Imms,

1934). Because the epimeron is slightly low-levelled than the episternum, a shallow groove results along the pleural suture (*PlS*).

(3) The prosternum (Fig. 22) assumes the form of a stalked goblet-like structure occupying the major median portion of the ventral aspect. It exhibits the following sclerites :

(a) The presternum (*Prs*) is represented by a very narrow band-like area existing as a rim along the ventral margin of the anterior foramen.

(b) The basisternum (*Bs*) lies anterior to the fore coxal cavities (*CxC*) and represents the largest prosternal sclerite. As the pleurosternal sutures (*PlSt*) diverge anteriorly, the basisternum is broader in front. It is convex ventrally, especially its posterior region.

(c) The sternellum (*Sl*) comprises a small posterior and median area situated anteriorly between the fore coxal cavities (*CxC*) and posteriorly between the inner epimeral ends. It is flask-like and is somewhat more sclerotized, bearing internally a furca (Figs. 21, and 23, *Fu*). Behind the furca and on the internal posterior region of the sternellum (Fig. 23) there is an internal plate which forms with the sternellum two lateral internal articular areas (*Art*) for the ends of the epimera (Fig. 22, *Epm*).

The prothoracic trochantin is represented by two triangular sclerites (Fig. 22, *Tn*) which are unequal in size. The smaller one is located at the anterior margin of the coxal cavity (*CxC*), behind the basisternum (*Bs*), while the other larger one extends into the episternum, covering the outer region of the coxal cavity. At the extreme outer end of this last plate, there is an internal sclerotized tendon connected laterally to the pronotum near the carinated lateral margin.

b. Mesothorax

The mesothorax is the smallest thoracic segment. It consists of :

(1) The mesonotum (Fig. 24) which is the shortest and the narowest thoracic tergum. Its major surface is concealed by the pronotum anteriorly and by the elytra laterally. A small posterior elevated area of the mesonotum is exposed between the basal inner margins of the elytra (Fig. 1). The mesonotum is less sclerotized than the pronotum but more so than the metanotum. It consists of the following sclerites.

(a) The prescutum (Figs. 24, and 25, *Prsc*) is represented only by the concave sclerotized anterior rim of the mesonotum. It bears the prephragma (Fig. 25, *APh*) internally.

(b) The scutum (Figs. 24, and 25, *Sct*) occupies the anterior two-thirds of the mesonotum. Its antero-lateral regions project anteriorly (*Pal*) while its straight or slightly concave lateral margin ends posteriorly with a comparatively large, round and much sclerotized projection representing the posterior wing process (*PNP*). This lateral margin is flexed internally form-

ing a vertical plate (Fig. 25, *Z*) which, together with the posterior wing process, prepare a suitable location for the condyle of the first axillary sclerite (*1Ax*). The wavey scuto-scutellar suture (Fig. 24, *vs*) which demarks the scutum (*Sct*) anteriorly from the scutellum (*Scl*) posteriorly, forms both the posterior and the postero-lateral limits of the scutum.

The scutum is divided into two equal parts by a longitudinal median suture (*i*) extending throughout its length and forming internally a well developed median apodeme (Fig. 25, *I*) which tapers in its anterior end (*w*) where the membranous prephragmal lobes (*o*) are attached. Each of the latter lobes extends internally between the antero-lateral projection of the scutum (*Pal*) and the tapering anterior portion (*w*) of the median apodeme (*I*). The inner portion of each prephragmal lobe forms a pocket on one side of this tapering portion (*w*) of the median apodeme while the outer portion of the lobe is connected to the lateral flexed plate (*z*) by a continuous membrane (*p*) which forms another lateral and larger pocket underneath the antero-lateral region of the scutum.

(c) The scutellum (Figs. 24, and 25, *Scl*) is represented by the posterior one-third area of the mesonotum. It is bounded anteriorly by the scuto-scutellar suture (Fig. 24, *vs*) which is ridged internally (Fig. 25, *VR*). The lateral scutellar margins are straight and parallel. The caudal scutellar region narrows posteriorly adapting a V-shaped aspect. A reversed notal suture (Fig. 24, *rvs*) of Snodgrass (1935) runs parallel to the V-shaped posterior marginal rim.

Two very narrow band-like areas of the scutellum (Fig. 24, *y*) extend laterally along the postero-lateral limits of the scutum and end behind the posterior wing process (*PNP*). They are more or less vertical exhibiting larger setae and forming obtuse angles with the lateral margins of the proper scutellum.

The anterior region of the scutellum is concave, being low-levelled than both the scutum and the posterior scutellar region which is elevated and thus could be exposed between the basal portions of the elytra (Fig. 1). When the elytra are removed this posterior scutellar region overlaps the anterior median area of the metanotum.

(d) The postscutellum of the mesonotum in Coleoptera is generally reduced or rarely developed (Snodgrass, 1907, and Crampton, 1918) owing to the tendency of the meso-scutellum to overlap the metanotum (Crampton).

In the confused flour beetle a low-levelled membranous area (Fgis. 24, and 25, *Mb*) exists on either side of the front portion of the scutellum (*Scl*). A small sclerotized and triangular plate (*n*) supports the attachment of this membrane with the lateral margin of the scutellum. Posteriorly,

there is a marginal and fairly sclerotized band-like structure (*AxC*) which meets and fuses with the corresponding one of the other side forming an

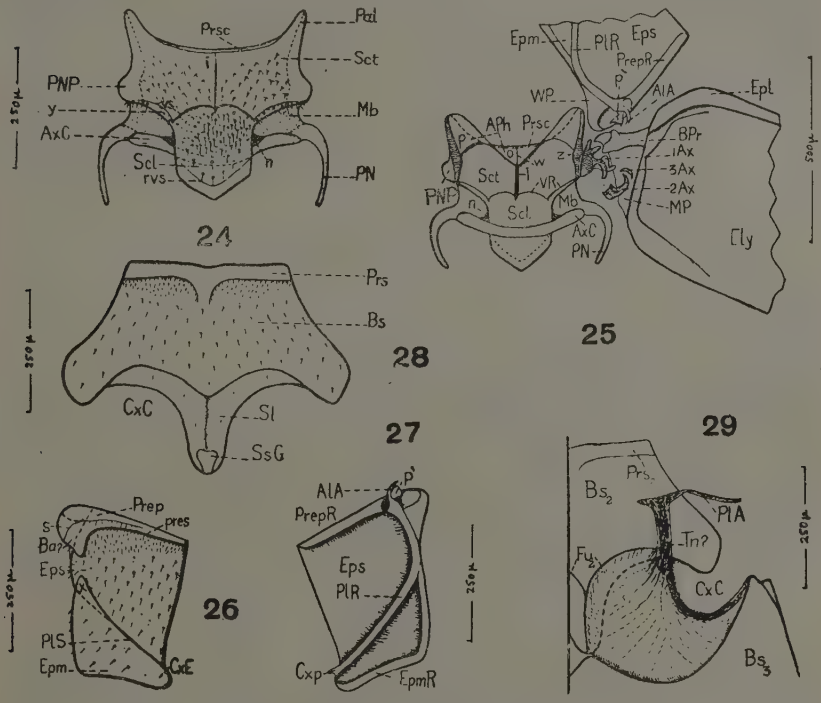


Fig. 24: The mesotergum, dorsal view. — Fig. 25: The mesotergum and its articulation with the elytron and mesopleuron, internal view. — Fig. 26: The mesopleuron, external view. — Fig. 27: The mesopleuron, internal view. — Fig. 28: The mesosternum, ventral view. — Fig. 29: The middle coxal cavity with the adjacent areas of the meso- and the metasternum, internal view.

(*AlA*, alar apophysis; *Aph*, anterior phragma; *Ax*, axillary sclerite (numbers refer to the number of the sclerite); *AxC*, axillary cord; *Ba?*, a sclerite probably representing a fused basalare; *BPr*, basal process of the elytron; *Bs*, basisternum; Bs_2, basisternum of the mesothorax; Bs_3, same metathorax; *CxC*, coxal cavity; *CxE*, epimeral extension for enclosing the coxal cavity laterally; *Cxp*, coxal process; *Ely*, elytron; *Epl*, epipleuron; *EpmR*, epimeral ridge; *Eps*, episternum; Fu_2, meso-furca; *I*, median ridge or carine; *i*, median suture; *Mb*, membrane; *MP*, median plate; *n*, sclerotized plate; *o*, lobe of the phragma; *p*, membranous structure connected to the phragmal lobe; *p'*, parapterum; *Pal*, antero-lateral projection of the scutum; *PlA*, pleural arm; *PlR*, pleural ridge; *PlS*, pleural suture; *PN*, postnotum (postscutellum); *PLP*, posterior notal process; *Prep*, pre-episternum; *PrepR*, pre-episternal ridge; *pres*, pre-episternal suture; *Prs*, presternum; *Prsc*, prescutum; *rvs*, reversed notal suture; *s*, suture; *Scl*, scutellum; *Sct*, scutum; *Sl*, sternellum; *SsG*, epinasternal groove; *Tn?*, a scelerotized internal plate, possibly a trochantin; *VR*, scutoscutellar ridge; *vs*, scutoscutellar suture; *w*, tapering portion of the ridge; *x*, anterior extension of the epimeron; *y*, lateral area of the scutellum; *z*, lateral flexed plate of the mesonotum).

internal ridge underneath the scutellum (Fig. 25). The whole structure represents the axillary cord of Snodgrass (1907) and Balfour-Browne (1932). Continuous with both the membranous area and the axillary cord laterally, there is another fairly sclerotized small plate representing the postscutellum (Figs. 24, and 25, *PN*) of Snodgrass (1907). This is connected distally to the metanotum.

(2) The mesopleuron (Figs. 26, and 27) occupies the lateral side of the mesothorax and is divided by the pleural suture (Fig. 26, *Pls*) which runs obliquely, into a larger anterior episternum (*Eps*) and a smaller posterior epimeron (*Epm*).

(a) The episternum in turn is divisible into :

(aa) The pre-episternum (Fig. 26, *Prep*) is represented by an anterior transverse and band-like sclerite extending along the anterior pleural margin, and bounded posteriorly by the pre-episternal suture (*pres*). It is broader dorsally with a round antero-dorsal angle and a right antero-ventral one. The dorsal portion of the pre-episternal suture (*pres*) extends somewhat posteriorly allowing for the formation of an extention (*Ba?*) of the dorsal pre-episternal region. As this extension is more raised than the general level of the episternum (*Eps*) and as it is differentiated from the pre-episternum by a distinct suture (*s*), it may, according to Crampton (1927), be considered as representing a fused epipleurite or basalare.

The anterior pre-episternal margin is strongly ridged internally (Fig. 27, *PrepR*). The dorsal portion of this ridge lies in the neighbourhood of the mesonotal posterior wing process.

(bb) The episternum (Fig. 26, *Eps*) is nearly a triangular area located between the pre-episternum anteriorly and the pleural suture posteriorly. Its front region is less sclerotized, possessing dense setae devoid of the common pits which occur on its remnant larger posterior region.

A triangular area arises from the antero-dorsal region of the episternum but is flexed internally underneath the broader dorsal area of the pre-episternum. The pleural ridge (Fig. 27, *PlR*) runs along the ventral margin of this process and extends somewhat anteriorly forming the alar apophysis (*AlA*) of Snodgrass (1907). This latter supports a very small plate (*p'*), the parapterum of this author, which is not so clear in some specimens.

(b) The epimeron (Fig. 26, *Epm*) is the smaller and triangular posterior region of the pleuron. It lies in a level different to that of the episternum with its posterior and dorsal margins ridged internally (Fig. 27, *EpmR*). Its antero-dorsal area (*x*) extends slightly anteriorly overlapping the pleural suture in this region. The round postero-ventral epimeral region (*CxE*) projects between the meso- and the meta-sternum enclosing the middle coxal cavity laterally and bearing internally (Fig. 27), at the end of the pleural ridge (*PlR*), the coxal process (*Cxp*) which articulates with the middle coxa.

(3) The mesosternum (Fig. 28) is a w-shaped structure the posterior arms of which are produced by two symmetrical caudal incisions forming partly the middle coxal cavities (Figs. 28, and 29, *CxC*). Its lateral margins diverge posteriorly and are slightly concave. The mesosternum consists of :

(a) The presternum (Fig. 28, *Prs*) is a narrow band-like marginal sclerite located along the anterior straight margin of the mesosternum. It displays a median caudal extention into the basisternum (*Bs*). This extention ends at a short distance without any visible caudal suture.

(b) The basisternum (*Bs*) constitutes the major surface of the mesosternum, including the posterior lateral arms which are round in their rear ends. Its lateral margins run parallel with the ventral mesopleural margins. The anterior region of the basisternum which is located on either side of the caudal extention of the presternum, is less sclerotized with setae devoid of the common pits.

(c) The sternellum (*Sl*) includes the entire median arm which projects more posteriorly than the lateral arms and it also ocupies the regions located along the antero-mesal margins of the middle coxal cavities (Fig. 28, *CxC*). Its furca (Fig. 29, *Fu2*) is well developed internally.

(d) The spinasternum (Fig. 32, *Ss2*) is represented by a small triangular structure completely detached from the mesosternum and entirely attached to the median metasternal process by its narrowest caudal portion. It is strongly sclerotized and is inserted firmly in a simlar shaped fossa (Fig. 28, *SsG*) grooved in the hind end of the mesosternellum (*Sl*).

On either side of the meso-spinasternum (Fig. 32) there is a band-like and similarly sclerotized marginal plate (*Pc*) completely attached to the metasternum along the posterior margin of the middle coxal cavity (*CxC*). This plate represents a fused « postcoxale » and is strongly ridged internaly.

No other sclerites are visible around the middle coxal cavity. Snodgrass (1907) records that the mesothoracic trochantin in Coleoptera is generally reduced or may be concealed within the coxal cavity, being represented, according to this author, by a lateral sclerotized area of the latter to which the head of the coxa articulates. According to this view, the sclerotized structure (Fig. 29, *Tn ?*) in the coxal cavity (*CxC*) of the confused flour beetle articulates internally with the head of the middle coxa and may represent, consequently, a concealed trochantin. From the latter plate (*Tn ?*) a finer sclerotized apodeme representing the pleural arm (*PlA*) arises anteriorly and extends laterally fusing after a short distance with the mesopleural ridge (Fig. 27, *PlR*).

c. Metathorax

The metathorax consists of the metanotum, the metapleura, and the metasternum.

(1) The metanotum (Fig. 30) is entirely concealed by the elytra when at rest. It is larger in area than the mesonotum but smaller than the pronotum and it differs also from both by being consisted of more or less membranous sclerites differentiated by more sclerotized limits. It is broader than long and is slightly convex dorsally. It is pushed in front till its caudal margin becomes dorsal to nearly the middle metasternal region. It consists of :

(a) The prescutum, being well developed as the case in most Coleoptera (Snodgrass, 1927, and 1935), occupies a comparatively large area along the front metanotal margin. It includes :

(aa) The median prescutal area (Fig. 30, *MPrA*) is a crescentic region occupying the anterior median region of the metanotum. When at repose, it is vertical with only its posterior limit conspicuous dorsally. It has two antero-lateral sclerotized arms (*PhAr*) tapering distally and run parallel with the meso-postscutellar plates (Figs. 24, and 25, *PN*) to which they are finally connected by their ends.

(bb) The prealare (Fig. 30, *Pal*) of Crampton (1916, and 1918) occurs on either side of the median prescutal area and is, likewise, fairly sclerotized and more or less vertical. It is roughly square with its inner anterior area projecting along the outer side of the arm (*PhAr*) of the median prescutal area.

(cc) The median prescutal membrane (*MPrM*) lies behind the median prescutal area and connects the latter with the scuto-scutellar region of the metanotum.

(dd) A lateral prescutal membrane stretches between the prealare (*Pal*) mesally and the anterior notal process (*ANP*) laterally. It contains two structures, the outer one representing the muscle disk (*MDi*) of Crampton (1918) while the other one (*AD*) corresponds to the anterior disk of Hopkins, 1909 (after Sayed, 1940). A pocket (*p*) is formed internally (dotted in Fig. 30) by both the prealare and this lateral prescutal membrane and is located underneath the front region of the scutum.

The anterior notal process (*ANP*) to which the first axillary sclerite (*1Ax*) articulates, lies at the antero-lateral angle of the metanotum.

(b) The scutum is represented by two large lateral areas separated by the median scutellum. Each scutellal area is subdivided into three smaller sclerites by two intrascutal sutures (*j*, *s*). The nearly transverse suture (*j*) differentiates an anterior scutal lobe (*AScL*) from a posterior one (*PScL*). The other longitudinal suture (*s*) marks off a third lateral scutal lobe (*MarL*) along the lateral margin of the metanotum. This latter lobe exhibits the posterior notal process (*PNP*) to which the third axillary sclerite of the

hind wing is connected. A muscle disk (Fig. 31, *MD*) with two very short stalks is visible posterior to this process (*PNP*).

(c) The scutellum (Fig. 30) occupies the median region of the metanotum between the two lateral scutal regions. It consists of :

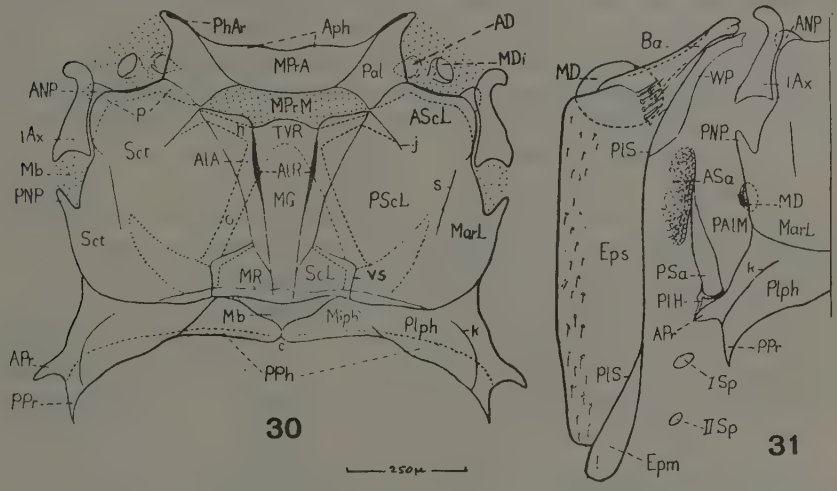


Fig. 30 : The metanotum, dorsal view. — Fig. 31 : The metapleuron, external view. (*AD*, anterior muscle disk; *AlA*, raised area lateral to the alar ridge; *AlR*, alar ridge; *ANP*, anterior notal process; *Aph*, anterior phragma (prephragma); *Apr*, anterior process of the postnotum; *ASa*, anterior subalare; *AScl*, anterior scutal lobe; *1Ax*, first axillary sclerite; *Ba*, basalare; *c*, incision; *Epm*, epimeron; *Eps*, episternum; *j*, suture; *k*, suture; *MarL*; lateral lobe of the scutum; *Mb*, membrane; *Md*, muscle disk; *MDi*, outer muscle disk; *MG*, median groove; *Miph*, mediophragmite; *MPrA*, median prescutal area; *MPrM*, median prescutal membrane; *MR*, marginal ridge; *p*, internal pocket of the scutum; *Pal*, prealare; *PAlM*, membrane between notum and pleuron; *PhAr*, phragmal arm; *PlH*, pleural hook; *Plph*, pleurophragmite; *PlS*, pleural suture; *PNP*, posterior notal process; *Pph*, postphragma; *PPr*, posterior process of the postscutellum; *PSa*, posterior subalare; *PScl*, posterior scutal lobe; *s*, suture; *Sct*, scutum; *ScL*, lateral lobe of the scutellum; *ISp*, first abdominal spiracle; *IISp*, second abdominal spiracle; *TVR*, transverse plate at the anterior area of the median groove, with its internal apodemes (*o* and *n*); *vs*, scutoscutellar suture; *WP*, pleural wing process).

(aa) The median groove (*MG*) of Snodgrass (1907) is represented by a longitudinal median region, broader anteriorly and flanked on either side by a strong apodeme ridged internally. This apodeme represents the alar ridge (*AlR*) of Crampton (1918) which serves, according to this author, to hold the elytra in place when at rest. On the outer side of this apodeme there is an elevated and fairly sclerotized area (*AlA*) limited anteriorly and laterally by finer apodemes.

At the anterior region of the median groove (*MG*) and behind the median prescutal membrane (*MPrM*) there is an external fairly sclerotized

plate (*TVR*) from which four apodemal arms (*n*, *o*) arise and extend internally (dotted in Fig. 30). Of these four arms, two (*n*) are short and nearly transverse ending at the anterior portion of the intrascutal suture (*j*) while the other two arms (*o*) diverge backwards ending at the lateral portion of the scuto-scutellar suture (*vs*) which is strongly ridged internally at the meeting-point.

(bb) Two lateral scutellar lobes (*Scl*) are located each on one side of the posterior portion of the median groove. They are differentiated from the posterior scutal lobes (*PScL*) by the scuto-scutellar suture (*vs*) which is more or less ridged internally.

A transverse and fairly sclerotized band-like structure, the marginal ridge (*MR*) of Snodgrass (1907), extends along the posterior limit of the scuto-scutellar area of the metanotum and supports the axillary cords of the hind wings. The alar ridges (*AlR*) reach the marginal ridge posteriorly.

(d) The postscutellum is a transverse sclerite occupying the rear region of the metanotum and considered by Snodgrass (1907, 1927, and 1935) as derived from the first abdominal tergite ; hence termed the « pseudonotum ». This author considers the median membrane (*Mb*) separating the postscutellum from the scutellum as the actual end of the metanotum.

The postscutellum is inclined more or less internally, bearing posteriorly a well developed two-lobed and vertical postphragma (*Pph*). It is termed the « phragmite » by Crampton (1914) and is divided by a median incision (*c*) into two symmetrical parts. Each part is subdivided by an oblique suture into an inner and a lateral areas called the « mediophragmite » (*Miph*) and the « pleurophragmite » (*Plph*) respectively. The latter sclerite has two lateral processes, the anterior of which (Fig. 31, *APr*) is connected to the metapleural epipleurite (*PSa*) (will be discussed later) by a sclerotized curved rod (*PlH*), the metapleural hook of Hopkins, 1909 (after Sayed, 1940). The posterior process (Figs. 30, and 31, *PPr*) is inclined ventrally. A suture (*k*) arises from it and runs antero-mesally in the lateral region of the pleurophragmite (*Plph*). The first abdominal spiracle (Fig. 31, *1Sp*) lies in the membrane enclosed between these two processes but somewhat further.

(2) The metapleura (Fig. 31) extend backwards so that their posterior ends reach the third abdominal segment (Fig. 46). The longitudinal pleural suture (Fig. 31, *Pls*) divides each pleuron into a larger episternum (*Eps*) and a reduced posterior epimeron (*Epm*) and is continuous in front in a well developed pleural wing process (*WP*).

(a) The episternum (*Eps*) constitutes the major pleural region visible mainly from the ventral aspect with its mesal margin coinciding with the lateral metasternal one. Its posterior region narrows gradually backwards

while the limits of its larger anterior region are nearly parallel. Its sclerotization is not uniform, being much stronger towards the mesal margin.

(b) The epimeron (*Epm*) is represented by a small sclerite located posterior to the episternum and is similarly sclerotized. It is round posteriorly forming with the hind region of the episternum an incision serving to receive the outer portion of the hind coxa.

The pleural wing process (*WP*) is a semi-membranous triangular structure arising from the antero-lateral region of the metapleuron and articulating dorsally with the first axillary sclerite (*1Ax*) and also with the head of the subcostal vein in the hind wing. The pleural suture (*Pls*) continues into it.

(c) The metapleural epipleurites consist of :

(aa) The basalare (*Ba*) is a process arising from the antero-lateral region of the episternum and located anterior and adjacent to the pleural wing process (*WP*) but is broader at base than the latter. It is entirely attached to the episternum and articulates distally with the head of the costal vein. A large funnel-like muscle disk (*MD*) of Snodgrass (1907) lies internally underneath the front episternal region and articulates by the end of its long stalk with the distal ends of both the basalare (*Ba*) and the pleural wing process (*WP*).

(bb) The subalares are represented by two other plates located in the membrane (*PALM*) occurring between the metapleuron and the metanotum behind the pleural wing process (*WP*). The anterior plate represents the anterior subalare (*ASa*) which is nearly oval with non-uniform sclerotization. The other plate represents the posterior subalare (*PSa*) which is leaf-like, narrowing out anteriorly and finally connects with the anterior subalare. The metapleural hook (*PLH*) connects it posteriorly with the front process (*APr*) of the meta-postscutellum. The subalares are less sclerotized than the metapleuron.

(3) The meso- and the metasternum combined are nearly trapezoidal-like structure, the lateral larger margins of which diverge backwards. While the mesosternal lateral margins are somewhat concave (Fig. 28), those of the metasternum (Fig. 32) are slightly convex. The middle coxal cavities (Fig. 28, and Fig. 32, *CxC*) lie between the meso- and the metasternum causing the posterior margin of the former and the anterior margin of the latter to be symmetrically incised and, consequently, possessing each, one median and two lateral processes. The metasternal median process bears the meso-spinasternum (Fig. 32, Ss_3) which, as mentioned on page 195, articulates with a suitable groove located in the caudal region of the mesosternal median process. This articulation strengthens the attachment of the meso- and metasternal median processes which separate the two middle coxal

cavities externally while the meso-furca (Fig. 29, Fu_2) separates them internally.

As previously stated, the metasternal anterior margin bears the meso-spinasternum (Fig. 32, Ss_2) medially and the postocoxale (*Pc*) laterally. No presternum is distinguished and, according to Snodgrass (1955), no spinasternum could be possessed by the metasternum posteriorly. Accordingly, the metasternum consists only of two sclerites, the basisternum and the sternellum. These two sclerites, however, are not definitely distinguished from each other owing to the absence of a transverse suture between them but they can be approximately identified as will be illustrated presently.

A median sternal groove (Fig. 32, *mg*) arises longitudinally in the posterior portion of the metasternum and is ridged internally (Fig. 33, *MR*), especially in its caudal region (*SlP*). According to Snodgrass (1935), the basisternum (Fig. 32, *Bs*) is approximately represented by the anterior metasternal area, not divided by the median groove (*mg*), while the sternellum (*Sl*) includes the area located on both sides of this groove. Thus the median groove stands as the only reliable distinguishing structure between the two metasternal sclerites.

The median ridge (Fig. 33, *MR*) broadens posteriorly (*SlP*) where it meets with two other transverse ridges (*TR*) with corresponding external grooves (Fig. 32, *tg*) running parallel with the posterior metasternal margins but do not reach the lateral margins of the metasternum. The broad median ridged area (Fig. 33, *SlP*) possesses two fossae (*Fos*) for the articulation of an endoskeletal structure and exhibits two posterior projections (*PPr*) for the inner articulation of the hind coxae. It is incised medially (*c*). The band-like area enclosed between the two transverse grooves (Fig 32, *tg*) and the rear metasternal margins is called « the ante-coxal piece » (*ACxP*) by Comstock (1915) owing to its location anterior to the hind coxae. It exhibits a fading suture (*s*).

The rear margin of the metasternum is composed of two portions (Figs. 32, and 33) arising at a median incision (*c*) and directed antero-laterally forming more or less right angles with the lateral metasternal margins. Thus the median caudal region of the metasternum projects posteriorly separating, together with a median abdominal process, the hind coxal cavities medially. These latter occur between the metasternum and the third abdominal sternite as the first two sternites of the abdomen are infolded internally as will be illustrated later.

3. Metendosternite

The endoskeletal y-shaped metendosternite (Fig. 34) of Crowson (1938) articulates with two fossae (Fig. 33, *Fos*) in the ridged area (*SlP*) located internally at the posterior median region of the metasternum. It forms

with the latter an angle about 45° and is directed antero-dorsally in the metathoracic cavity. It assumes the shape of a longitudinal section of a goblet with the stalk consisting of three apodemes, one median stronger (Fig. 34, *MeA*)

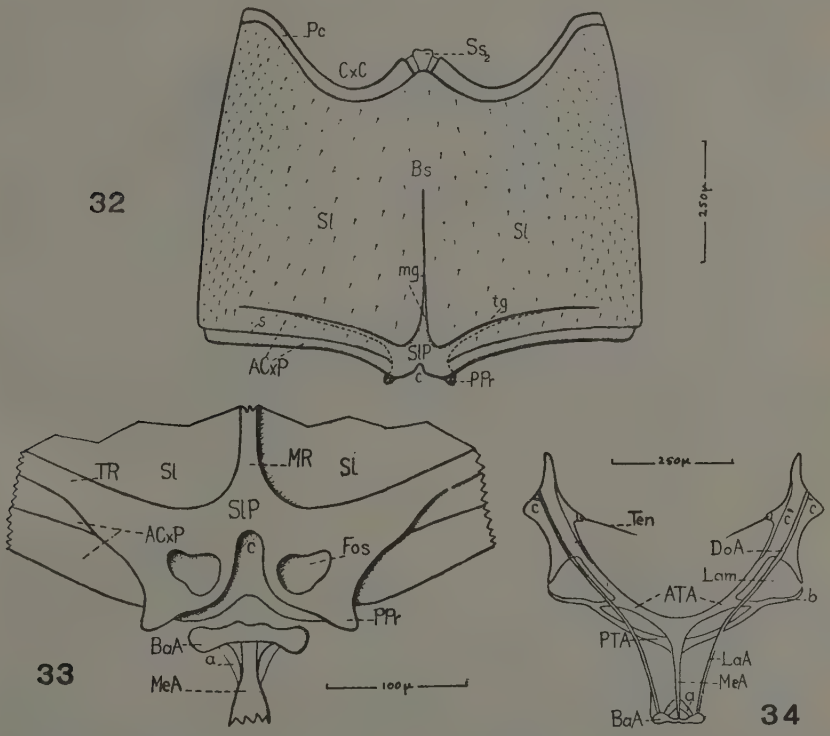


Fig. 32: The metasternum, ventral view. — Fig. 33: Median posterior region of the metasternum, internal view. — Fig. 34: The metendosternite.

(*a*, apodeme, supporting the median apodeme (*MeA*); *ACxP*, antecoxal piece; *ATA*, anterior transverse apodeme; *b*, arm of the transverse apodeme; *BaA*, basal apodeme; *Bs*, basisternum; *c*, incision; *c'*, wide distal region lateral to the anterior transverse apodeme; *CxC*, coxal cavity; *DoA*, dorsal apodeme; *Fos*, fossa; *LaA*, lateral apodeme; *Lam*, lamina; *mg*, median groove; *MeA*, median apodeme; *Mr*, median ridge; *Pc*, postcoxale; *PPr*, posterior process; *PTA*, posterior transverse apodeme; *s*, suture; *Sl*, sternellum; *SlP*, a median plate of the sternellum where external grooves (Fig. 32) or internal ridges (Fig. 33) meet; Ss_2, meso-spinasternum; *Ten*, tendon; *tg*, transverse groove; *TR*, transverse ridge).

and two finer lateral (*LaA*) ones. The three apodemes are connected at base with another transverse apodeme (*BaA*), the lateral round ends of which articulates with the fossae (Fig. 33, *Fos*) previously mentioned. The median apodeme (Fig. 34, *MeA*) tapers proximally and is supported at base by two small apodemes (*a*) arising from the basal transverse one (*BaA*). Distally,

it supports two other transverse apodemes, one behind the other. The anterior apodeme (*ATA*) is crescentic running on the inner side of the body of the metendosternite while the posteror one (*PTA*) runs parallel to the proximal portion of the former.

The lamina (*Lam*) is comparatively reduced in the confused flour beetle, being represented on either side by a small area located lateral to the anterior transverse apodeme which gives off a lateral branch (*b*) bordering the lamina posteriorly and finally fusing with the distal end of the posterior transverse apodeme (*PTA*). The lamina is bordered in front by a broad area (*c'*) located lateral to the distal end of the anterior transverse apodeme. The inner side of the latter portion of the apodeme bears the anterior tendon (*Ten*) of Crowson which is characteristically widely separated from the corresponding one of the other side.

The broad regions (*c'*), the reduced laminae (*Lam*) and the distal ends of the posterior transverse apodeme (*PTA*) are all directed ventro-laterally. On their dorsal surfaces and on either side of the metendosternite, there exists a finer apodeme (*DoA*) which is the continuation of the lateral longitudinal apodeme (*LaA*) of the stalk and which continues to the distal end of the metendosternite.

4. Elytra

The elytra cover the main lateral regions of the mesonotum, the entire metanotum and the whole abdominal tergites except the posterior portion of the seventh one which is the last visible tergite. They shelter the hind wings underneath them. Their anal margins meet mid-dorsally forming the « dorsal suture », and do not diverge posteriorly.

Each elytron (Fig. 35) is a keel-like structure, oblong in outline with the hind apex directed inwards. The elytral epipleuron (*Epl*) is a band-like area located along the costal margin and narrowing out towards the apex. One-fourth of the epipleuron from base is inclined ventrally (the only apparent epipleural region drawn in Fig. 35), while its remnant region is nearly vertical and is only visible from the lateral aspect. The epipleural free margin is not straight, but is concave somewhat medially. The other or dorsal epipleural limit which is the costal margin of the elytron, is strongly carinated. This costal margin presents near the elytral apex a slight concave portion (Figs. 35, and 36, *c*) which receives the lateral process of the seventh abdominal sternite (to be mentioned later).

When the elytra are closed at rest, their anal margins which apparently seem to lie side by side, are articulated after the fashion illustrated by Allnaud (1902) in Coleoptera [mortaise à gauche, tenon à droite]. In the confused flour beetle a very narrow and less sclerotized band (Figs. 35, and 36, *Art*) exists along each elytral anal margin but is especially clear at the

apex. That of the left elytron forms with its anal margin a very shallow groove (la mortaise) which receive the band (le tenon) of the right elytron. Very fine spurs (Fig. 36, *d*), existing at the apical portions of the bands, assure firm articulation.

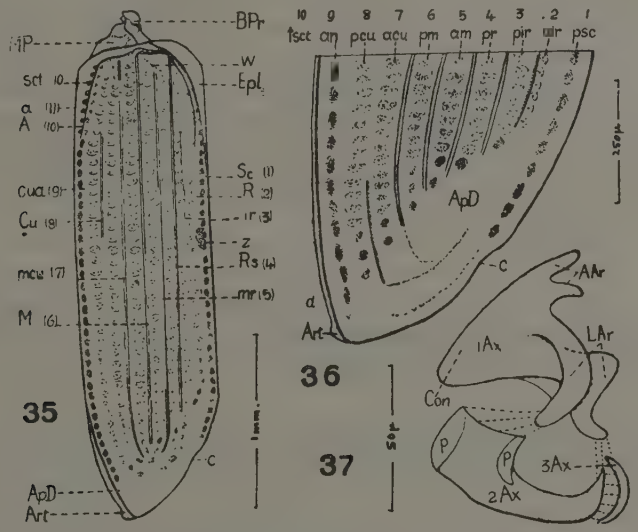


Fig. 35: The female left elytron, internal view. — Fig. 36: The male apical region of same, internal view. — Fig. 37: The elytral axillary sclerites, dorsal view.

(*AAr*, anterior arms of the first axillary sclerite; *ApD*, apical disk; *Art*, anal marginal area for articulation; *Ax*, first (*1Ax*), second (*2Ax*) and third (*3Ax*) axillary sclerites; *BPr*, basal process of the elytron; *c*, incision; *d*, small spurs confirming articulation; *Epl*, epipleuron; *LAr*, lateral arms of the first axillary sclerite; *MP*, median plate; *p*, plates in the second axillary sclerite; *w*, slight internal sclerotization with a corresponding slight external depression; *z*, ridge).

Elytral veins: *Sc* (1), subcostal; *R* (2), radius; *ir* (3), secondary interradial; *Rs* (4), radial sector; *mr* (5), secondary radiomedial; *M* (6) media; *mcu* (7), secondary mediocubital; *Cu* (8), cubitus; *cua* (9), cubitoanal; *A* (10), anal; *a* (11), second anal.

Elytral striae; 1 *psc*, post subcostal; 2 *air*, anteinterradial; 3 *pir*, postinterradial; 4 *pr*, postradial; 5 *am*, antemedial; 6 *pm*, postmedial; 7 *acu*, antecubital; 8 *pcu*, postcubital; 9 *an*, anteanal; 10 *sct*, interanal (Fig. 35).

The elytron of the confused flour beetle (Fig. 35) is much sclerotized with longitudinal straight and non-branching veins. The cells between the veins are arranged in longitudinal furrows (Fig. 36, from 1 to 10), the striae of Richter (1935-36). The veins are represented by the interspaces (Fig. 35, from 1 to 11) between the striae which are best seen from the inside of the elytron. Ten striae and eleven interspaces or veins are present in the elytron of the confused flour beetle. According to Richter (who gives a list of the

elytral veins in Tenebrionidae), and according to the elytral tracheal venation, the eleven interspaces are as follows (Fig. 35).

Interspace 1 represents the subcostal vein (*Sc*) as the costal one (*C*) is atrophied in most Coleoptera (Richter). It runs parallel to the costal margin and is concealed near the base (ventrally) by the ventral inclination of the epipleuron (*Epl*). It has a fine trachea and, consequently, represents a principal vein.

Interspace 2 represents the radius (*R*) and lies next to the subcostal (*Sc*). It presents a distinct internal ridge at base and another shorter one (*z*) at its middle region. Its distal portion shows a more pigmented longitudinal line with a corresponding external weak carina or ridge. It has a fine trachea.

Interspace 3 has no trachea and represents a secondary interradial vein (*ir*).

Interspace 4 represents the radial sector (*Rs*) but, as it possesses no visible trachea, it may represent another secondary inter-radial vein.

Interspace 5 represents the secondary radiomedial vein (*mr*) and possesses no trachea.

Interspace 6 represents the media (*M*) and has a fine trachea.

Interspace 7 represents the secondary mediocubital vein (*mcu*) and has no trachea.

The last four interspaces (4, 5, 6 and 7) have distinct differentiated longitudinal lines of pigmentation with corresponding external carinae or ridges extending from the base of the elytron but do not reach its apex owing to the presence of a non-striated area, the apical disk (Figs. 35, and 36, *ApD*). This latter is sexually differentiated, being wider in the male (Fig. 36, *ApD*) than in the female (Fig. 35, *ApD*), owing to the different distal arrangement of the lines of pigmentation (with their adjacent striae) and their distal corresponding external ridges of these four interspaces in the two sexes. In the male (Fig. 36) these lines of pigmentation gradually approach the apex; that of interspace 7 is nearer to apex than that of interspace 6 and, likewise, that of 6 is nearer to apex than that of 5, and this is nearer than that of 4. This arrangement holds good with the corresponding external carinae. In the female (Fig. 35) the lines of pigmentation in interspaces 5 and 7 tend to meet distally and both are nearer to apex than that of interspace 6 which is still nearer than that of interspace 4. This arrangement also holds good with the corresponding external carinae. Accordingly, the male apical disk (Fig. 36, *ApD*) is wider than the female one (Fig. 35, *ApD*). This disk, together with the arrangement of the distal portions of the external carinae in its neighbourhood, are very successful in differentiating the two sexes externally (Fig. 1).

Interspace 8 represents the cubitus (Fig. 35, *Cu*) and has a fine trachea.

Interspace 9 represents the cubito-anal vein (*cua*) and has no trachea.

Interspace 10 represents the first anal (*A*) and has a short basal internal ridge extending for about one-seventh of the whole length of the anal margin towards which it directs. At the distal end of this ridge, interspace 10 continues along the anal margin. It has a fine trachea.

Interspace 11 represents the second anal (*a*). It is short for it merges in interspace 10 at the distal end of the ridge in the latter interspace.

The ten striae (Fig. 36) are named according to the adjacent veins and their names (according to Richter) are mentioned in the explanation of Figures 35-37 and, therefore, will not be mentioned here. The points of these striae, the trabeculae of Imms (1934), differ in degree of pigmentation, in size and shape. In general, those near the anal and costal margins or near the apical disk are more pigmented, oval and smaller while the other points are less pigmented and not completely circular.

Articulation of the elytron : Three axillary sclerites (Fig. 25, and Fig. 37) are associated with the mesonotal posterior wing process (*PNP*). These are :

(1) The scapular or the first axillary sclerite (*1Ax*) is an irregular plate with a large condyle (Fig. 37, *Con*) connected to the posterior wing process of the mesonotum. It has an anterior incised arm (*AAr*) articulating with the elytral basal hinge process (Fig. 25, *BPr*) and two other arms (Fig. 37, *LAr*) connected with the second axillary sclerite.

(2) The subscapular or the second axillary sclerite (Figs. 25, and 37, *2Ax*) is a rough dish-like plate connected with the first and third axillary sclerites (*1Ax*, and *3Ax*) and also with an elytral basal plate (Fig. 25, *MP*), corresponding to the median plate of Sayed (1940).

(3) The flexor plate or the third axillary sclerite (Figs. 25, and 37, *3Ax*) is a small crescentic plate associated with the outer (or anterior) side of the second axillary sclerite (*2Ax*).

The parapterum (Fig. 25, *p'*) of the mesopleuron also articulates with a suitable projection in the elytral basal hinge process (*BPr*).

5. Hind wings

In (1922) Graham and Forbes each proposed a different system for wing venation in Coleoptera. Graham, because of the considerable variation he found out in the tracheation of the pupal wings even within a single species (e.g. *T. confusum*) neglected tracheation in his study. Forbes, on the contrary, based his description of veins on the main tracheation.

Perhaps, the causes of these varying views are well accounted for by Wilson (1930) who records : « The wing veins of Coleoptera present a problem upon which there has been little agreement by those who have

attempted to homologise venation. This is due to the unique and complicated course of veins and the transverse folding of the wings which interrupt the course of veins and cause distortions that make it very difficult to compare the Coleopterous venation with that of the other orders ». It is interesting to mention that Potter (1936), finding similar venation in different species, came to the conclusion that the wing venation in Coleoptera is not of considerable systematic value.

a. Shape and regions

As the costal and the anal margins of the hind wing are nearly parallel for their major proximal portions, the wing (Fig. 38) is elongated but roughly triangular in its apical area, the distal angle or apex of which is round.

The hind wing answers to all regions illustrated by Snodgrass (1935), exhibiting the « axillary region » containing the axillary sclerites (Fig. 39) and the true « ala » or wing. This latter presents the « remigium » (Fig. 38, *RM*) which occupies the antero-apical two-thirds of the wing surface, the « vannus » (*Vn*) which contains three anal veins and the jugum (*Ju*) which contains only one vein (*4th A*) and is sessile (Fig. 40, A and B, *J.J.'*). The vannal fold separating the two former areas is not developed, being only marked distally by a slight incision (Fig. 38, *vf*) in the anal margin. The jugal fold (*jf*) is well developed.

b. Venation

The veins are pushed to the basal region of the wing (Fig. 38) as frequently occurs in most Coleoptera (Forbes). The apical area is devoid of veins. The visible veins, according to Forbes (1922), are the following :

(1) The costa (*c*) has a free basal portion the proximal part of which is more sclerotized representing the humeral plate (*Hp*). This latter articulates proximally with the meta-basalare (Fig. 31, *Ba*). Then the costa merges in the next subcosta forming (*C* + *Sc*) where very short spurs are displayed (Fig. 39, *d*). The costa, after fusing with the subcosta for a short distance, continues as the mere costal margin of the wing.

(2) The subcosta (*Sc*) begins proximally with a free portion which articulates basally with both the first axillary (Fig. 39, *1Ax*) and the metapleural wing process (Fig. 31, *WP*). Then it becomes in close contact with the proximal portion of the next radius (Figs. 38, and 39, *R*) for a short distance after which it fuses with the costa forming (*C* + *Sc*) vein. Finally it fuses again with (*R*) forming (*Sc* + *R*).

(3) The radius (*R*) begins proximally in close contact with the subcosta. Then it separates from the latter to be again in close contact with the proximal portion of the cubitus (*Cu*) for a short distance. Then it runs freely

again for a comparatively larger distance after which it finally fuses with the subcosta forming $(Sc+R)$ vein which continues towards apex, parallel to the costal margin and ending about one-third of the entire length of the wing farther from apex. It is pointed distally where the recurrent radius (Rr) arises and directs posteriorly towards the base of the wing.

Between $(Sc+R)$ and the costal margin of the wing, there is a pigmented area, the pterostigma (Fig. 38, *Pts*) of Forbes and Imms, which is also pointed distally but is little longer apically than $(Sc+R)$ vein.

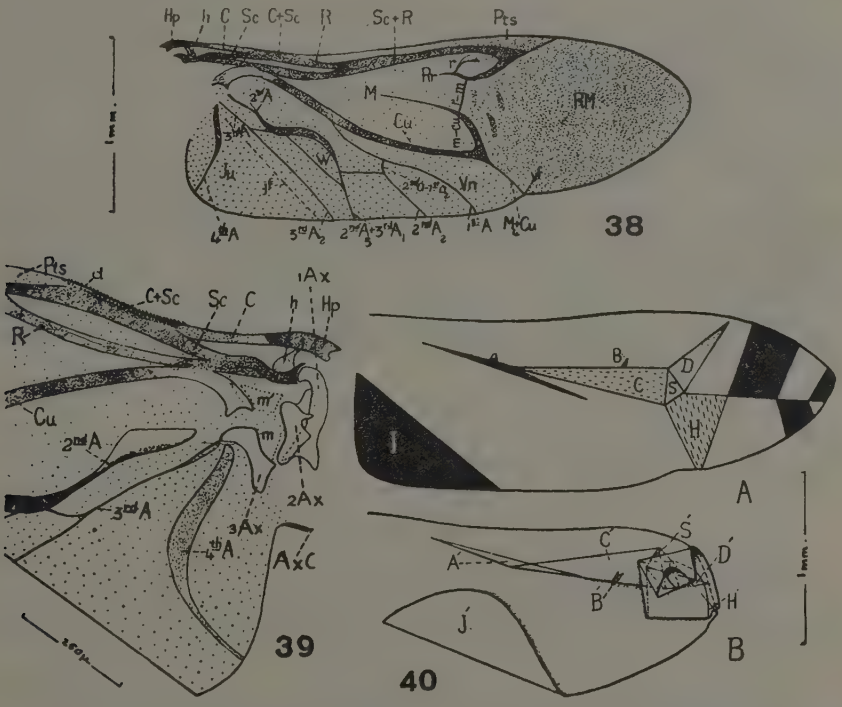


Fig. 38: The left hind wing, ventral view. — Fig. 39: The basal region of the right hind wing, with the thee axillary sclerites, ventral view. — Fig. 40: The wing folding pattern (A. The hind wing extended with the folded areas blackened, dotted or shortly-lined; B. The hind wing folded, ventral view).

For explanation refer to the Text.

(4) The media (M) is fading at base which lies far from the basal region of the wing. Distally it becomes stronger and curls towards the anal margin — this part is considered as a cross-vein — but before reaching the latter it fuses with the distal part of the cubitus forming $(M4+Cu)$.

(5) The cubitus (*Cu*) begins proximally with a swollen but fading head which arches anteriorly till it becomes in very close contact with (*R*) for a short distance after which it freely directs towards the anal margin, fusing distally with the media, thus forming ($M_4 + Cu$) of Forbes.

(6) The anal veins (Figs. 38, and 39) include:

(a) The 1st anal vein (*1st A*) splits off from the cubitus at a point one-third of its length from base, forming with it an acute angle, and is wavy.

(b) The second anal vein (*2nd A*) begins with a broad but very fading head near the distal end of the third axillary sclerite (*3Ax*). Then it thins out for a short distance after which it becomes thickly pigmented and broader arching strongly towards the cubitus. Distally it branches into the (*2nd* A_2) and the (*2nd* A_3) as the (*2nd* A_1) is lost (Forbes). The (*2nd* A_3) thins out and fuses with (*3rd* A_1) forming (*2nd* $A_3 + 3rd\ A_1$) vein.

(c) The third anal vein (*3rd A*) forks near the base into two branches; the (*3rd* A_1) and the (*3rd* A_2). The former shortly after branching becomes in « very » close contact with the proximal part of the thickly pigmented portion of (*2nd A*), with which it forms the wedge-cell (*w*). Finally it fuses with (*2nd* A_3). The (*3rd* A_2) takes the course of the stem and continues towards the anal margin, parallel to the jugal fold (*jf*) which lies posterior to it.

(d) The fourth anal vein (*4th A*) of Forbes (1922) or the jugal vein of this author (1932) is non-branching and is located in the jugum. It is stouter proximally but thins out distally arching slightly towards (*3rd A*).

c. Cross-veins

The visible cross-veins are :

(1) The humeral cross-vein (*h*) exists between the basal portions of (*C*) and (*Sc*) in the form of a triangular plate, with its apex directed towards (*C*).

(2) The radial cross-vein (*r*) lies between (*Rr*) and (*R*) but hardly reaches the latter. It arches distally towards the apex of the wing.

(3) The radio-medial cross-vein (*r-m*) extends between (*Rr*) and (*M*).

(4) The medio-cubital cross-vein (*m-cu*) is represented by the distal curling of (*M*) before its fusion with (*Cu*).

(5) A cross-vein (*cu-1st a*) occurs between (*Cu*) and (*1st A*) but is not conspicuous in the confused flour beetle, a characteristic of the species.

(6) The cross-vein (*1st a - 2nd* a_2) exists between (*1st A*) and (*2nd* A_2) and measures characteristically about one-third of the length of the proximal portion of (*2nd* A_2) which lies between this cross-vein and (*2nd* A_3).

d. Wing folding pattern

Forbes (1924 and 1926) studied the wing folding patterns in Coleoptera, believing that they are as significant as any of the characters used in the classification of this order. Following his nomenclature (1926), the « reversed areas » displayed by the folded wing of the confused flour beetle are (Fig. 40, A and B) :

(1) The jugal or axillary area (*J*) is a broader sessile area.

(2) The median area (*A*) is moderately developed and lies anterior to (*Cu*) extending nearly half way its length from base.

(3) The proximal pivot (*B*) is represented only by small crumples.

(4) The antemedian area (*C*) lies in front of (*Cu*) close to area (*A*) proximally, and is supported by (*M*), extending for nearly half way the length of (*Cu*) from distal region.

(5) The distal pivot (*D*) hardly reaches the costal margin immediately lateral to the pterostigma.

(6) The principal area (*H*) is well developed, reaching the anal margin.

(7) Other apical areas are in evidence, frequently two as in the figure.

The other areas of the wing (not blackened in Fig. 40, A), except the area (*S*), remain « upright ». The central area (*S*) remains upright because it is twice reversed. The anal folds are absent entirely. Figure 40 B shows the wing naturally folded.

e. Vestiture

The apical area (Fig. 38) is microscopically dotted owing to the presence of very minute pigmented structures, possibly the microtrichia of Imms (1934). The area located lateral to the cross-vein (*r-m*) presents three slightly more pigmented areas, indicating vestigial veins (Forbes). The remaining regions of the wing, except the veins and the pterostigma, are membranous. The costal margin at (*C* + *Sc*) is minutely serrated owing to the presence of short spurs (Fig. 39, *d*).

f. Articulation

The hind wing articulates by :

(1) The humeral plate (Figs. 38, and 39, *Hp*) represnts the base of (*C*), lies anterior to the first axillary sclerite and articulates ventrally with the meta-basalare.

(2) The first axillary sclerite (Fig. 39, *1Ax*) articulates by its anterior head with the subcosta (*Sc*) and ventrally with the metapleural wing process (Fig. 31, *WP*). It articulates mesally with the anterior notal process (Fig. 30, *ANP*) while it is partly embraced laterally by the second axillary sclerite (Fig. 39, *2Ax*). Posteriorly it is broader with an incised caudal margin.

(3) The second axillary sclerite (*2Ax*) is hinged to the outer margin of the first axillary.

(4) The third axillary sclerite (*3Ax*) lies in the posterior area of the axillary region, articulating proximally with both the caudal end of the second axillary sclerite (*2Ax*) anteriorly and the posterior wing process (Fig. 30, *PNP*) caudally. Its lateral side is associated with the proximal portions of the anal veins, except the (*1st A*).

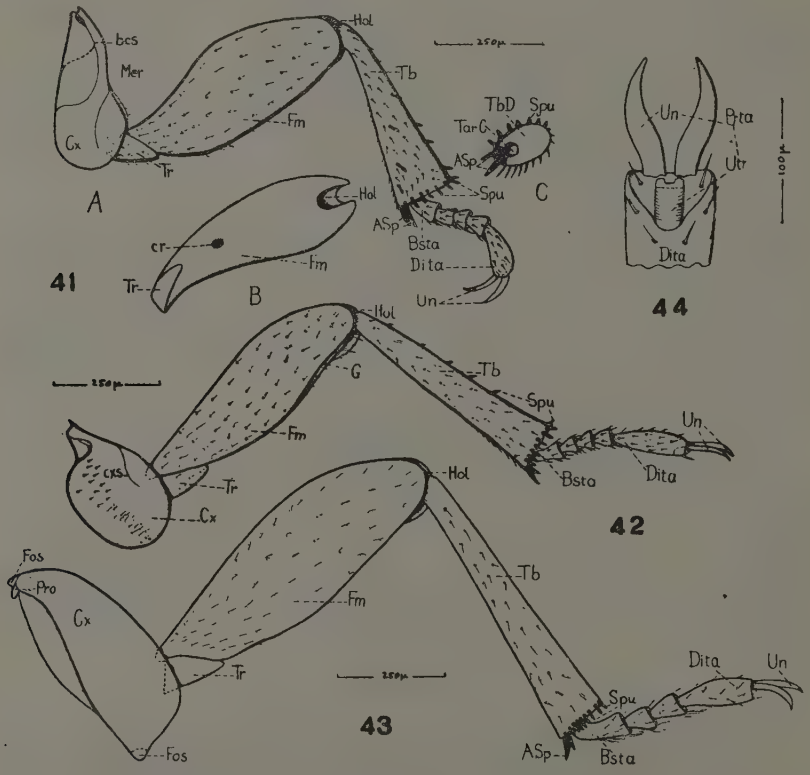


Fig. 41: A, The right fore leg, posterior view; B, The fore femur of the male, inner view; C, The tibial disk. — Fig. 42: The middle right leg, posterior view. — Fig. 43: The hind right leg, posterior view. — Fig. 44: The fore pretarsus, ventral view.

(*ASp*, apical tibial spur; *bcs*, basicostal suture; *Bsta*, basal segment of the tarsus; *cr*, circular area with dense small spurs in the fore femur of the male; *Cx*, coxa; *cxs*, coxal suture; *Dita*, distal segment of the tarsus; *Fm*, femur; *Fos*, fossa; *G*, groove; *Hol*, hollow of the femur; *Mer*, meron; *Pro*, process; *Prta*, pretarsus; *Spu*, spurs; *TarC*, tarsal cavity in the tibial disk; *Tb*, tibia; *TbD*, tibial disk; *Tr*, trochanter; *Un*, claw; *Utr*, unguitractor).

(5) The axillary cord (*AxC*) supports and connects the jugal margin to the caudal end of the meta-scutoscutellum, where the marginal ridge (Fig. 30, *MR*) confirms this connection.

(6) The median plates (Fig. 39, *m*, *m'*) are very slightly sclerotized, thus being liable to be overlooked. One lies anterior to the third axillary sclerite (*3Ax*) while the other extends between the head of (*Cu*) and the second axillary sclerite (*2Ax*).

6. Legs

When the confused flour beetle is laid upside down and gently touched, it ceases to move its legs for a while, a sign of deathfeining which is characteristic in most Coleoptera. In this position the insect tends to bring its legs within the limits of its body.

a. Coxa

The fore-coxa (Fig. 41 A, *Cx*) is cone-like with the base directed mesally and the top, concealed by the trochantin, directed laterally. Its lateral end connects with the trochantinal tendon. The basi-costal suture (*bcs*) of Snodgrass (1935) is distinct and the meron (*Mer*) is small.

The middle coxa (Fig. 42, *Cx*) is nearly spherical with a wavy ventral coxal suture (*cxs*) and an antero-lateral apodeme articulating with the coxal process at the end of the meso-endopleuron (Fig. 27, *Cxp*).

The hind-coxa (Fig. 43, *Cx*) is the largest and nearly oval with the coxal suture not distinct. It presents a shallow transverse depression. In the fore, middle and hind coxae, sclerotization becomes gradually more stronger ventrally.

b. Trochanters

The trochanters (Figs. 41, 42, and 43, *Tr*) are nearly similar in size and shape in all legs. Each is a triangular segment articulating with the inner proximal flat area of the femur and the two articulate proximally with the coxa. The trochanter is the smallest leg segment.

c. Femur

The femur (*Fm*) stands as the largest leg segment both in bulk and length. It is broader medially but tapers proximally and distally, reaching the coxa lateral to the trochanter. Its distal end is round presenting a socket (*Hol*) for the articulation of the tibia. The fore femur (Fig. 41, *Fm*) is comparatively broader medially than other femora and, moreover, shows sexual differentiation by bearing on its inner proximal region in the male (Fig. 41 B, *Fm*) a circular area (*cr*) with dense fine spurs. This latter is very obvious in cleared specimens.

d. Tibia

The tibia of each leg is slightly shorter, but distinctly slender than its own femur, being broader distally. Though the fore tibia (Fig. 41 A, *Tb*) is the shortest, its apical margin is the widest (Good, 1936). The articulation of the tibia with the femur is of the socket-and-ball type (Snodgrass).

The apical tibial disk (Fig. 41 C, *TbD*) is oval in all legs, possessing in its inner region a circular excavation, the tarsal cavity (*TarC*), for receiving the basal tarsal segment (Fig. 41 A, *Bsta*). Two long and stout apical spurs (Fig. 41 A and C, *ASp*) of the tibia arise in the region located between the tarsal cavity and the inner margin of the tibial disk. The posterior margin of the tibial disk bears short but stout spurs (*Spu*) while the anterior one bears longer but finer ones. All these marginal spurs are comparatively shorter than the two apical spurs (*ASp*) located on the inner region of the tibial disk.

Other short spurs are found on the outer side of the fore and the middle tibiae only (Figs. 41 A and 42, *Spu*). The inner side of all tibiae bears fine dense hairs especially at the distal portion. The fore tibia has some short but stout spurs distributed on its distal surface.

e Fore and middle tarsi

The fore and middle tarsi (Figs. 41 A, and 42) each is composed of five subsegments while the hind tarsus (Fig. 43) has only four. In each of these tarsi, the distal subsegment (Figs. 41 A, 42, and 43, *Dita*) is the longest while the basal one (*Bsta*) is longer than any of the other subsegments. The distal segment is broader distally where it carries the pretarsus (Fig. 44, *Prta*).

f. Pretarsus

The pretarsus is composed of two long, stout and slightly curved claws (*Un*) arising dorsally, and of a median ventral flexor plate or unguitractor (*Utr*) of Hays and Kearns (1934). The latter is round proximally with two parallel striated sides and distal medially incised margin. It is longer than broad. The pretarsus presents no other structures.

The legs of the confused flour beetle are adapted for walking and having fine dispersed setae all over the leg segments.

D. Abdomen

The confused flour beetle has ten abdominal segments in both sexes. These segments can be divided, for purpose of description, into the apparent segments, the hidden segments, and the genitalia.

1. Apparent segments

The apparent abdominal segments (Figs. 45, 46, and 47) are seven in both sexes with their tergites concealed under the elytra, except the posterior region of the seventh one.

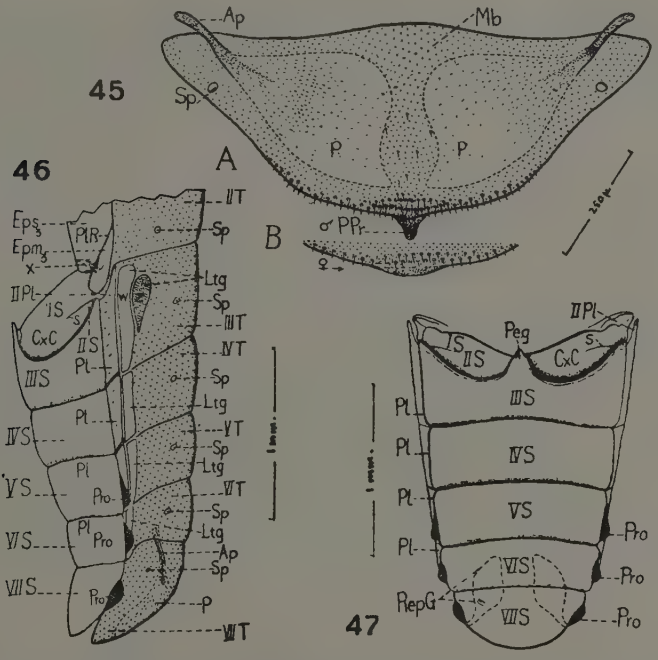


Fig. 45 : A, The last apparent abdominal tergite of the male, dorsal view; B, The posterior median area of same in the female. — Fig. 46 : The abdomen, left lateral view. — Fig. 47 : The abdominal sternites, ventral view.

(*Ap*, apodeme; *CxC*, coxal cavity; *Epm*$_3$, metepimeron; *Eps*$_3$, metepisterum; *Ltg*, latero-tergite; *Mb*, membrane; *p*, sclerotized plate; *Peg*, median sternal projection; *Pl*, pleurite; *PlR*, pleural suture; *PPr*, posterior process; *Pro*, process; *RepG*, abdominal repugnatorial gland (dotted); *S*, sternite (Roman numbers refer to the numbers of the abdominal segments); *s*, suture; *Sp*, spiracle; *T*, tergite (Roman numbers refer to the numbers of segments); *w*, outer latero-tergite of the third abdominal segment; *x*, sclerotized structure at the end of the metapleural ridge; *z*, inner latero-tergite of the third abdominal segment).

a. Tergites

As the meta-postscutellum is actually detached from the first abdominal tergites (Snodgrass), this latter is reduced in area but is distinguished by its pair of spiracles. The first six apparent tergites (Fig. 46) are so membranous that some of the internal abdominal organs (e.g. Malpighian tubes) can be seen through them. Their transverse limits are

not so conspicuous but the spiracles (*Sp*) are reliable in demarking their number. The seventh or last apparent tergite (Figs. 46, *VII T*, and 45 A) presents fair sclerotization concentrated in two symmetrical plates (*p*) while its periphery as well as its median region are still membranous (*Mb*). Each plate (*p*) exhibits a more sclerotized apodemal arm (*Ap*) directed antero-laterally and extending underneath the postero-lateral region of the sixth tergite. The round posterior margin of the seventh tergite is sexually differentiated, possessing in the male (Fig. 45 A) a median posterior and more sclerotized process (*PPr*), not found in the female (Fig. 45 B) where a crescentic and fairly sclerotized area is present instead. It is fringed with setae (in both sexes) which shorten gradually towards the sides.

Latero-tergites (Fig. 46, *Ltg*) occur as slightly more sclerotized regions on either side of the membranous abdominal tergites from the third to the sixth (*III T* to *VI T*). The third abdominal tergite (*III T*) presents two latero-tergites (*w* and *z*) on either side; the outer one (*w*) is much longer than broad and is located along the entire lateral tergal margin while the mesal one (*z*) is smaller and leaf-like, located adjacent to the anterior portion of the former latero-tergite (*w*) and is pointed posteriorly. Sclerotization is not uniform in the mesal latero-tergite (*z*). Each of the fourth (*IV T*), fifth (*V T*) and sixth (*VI T*) abdominal tergites has only one latero-tergite on either side (*Ltg*) which narrows gradually posteriorly. Consequently, the sixth latero-tergite is the narrowest and the shortest.

b. Sternites

The sternites (Figs. 46, and 47) are actually seven in number, but the first two (*IS* and *IIS*) are folded internally forming the hind coxal cavities (*CxC*) and are seen (after the removal of the hind coxae) attached to the anterior border of the third sternite (*IIIS*). Thus the apparent first abdominal sternite is really the third. This latter presents anteriorly one median and two lateral processes. Forbes (1925) considers this median process (Fig. 47, *Peg*) as belonging to the second sternite. Murray and Tiegs (1935) consider it as formed by the third sternite and call it « the peg ». This latter overlaps the median posterior region (Fig. 32, *SIP*) of the metasternum and the two separate the hind coxal cavities from one another medially.

The apparent sternites (Figs. 46 and 47), from the third (*IIIS*) to the seventh (*VIIS*) are heavily sclerotized with their anterior and posterior limits (except the anterior margin of the third and the posterior one of the seventh) nearly parallel. The seventh sternite (*VIIS*) is nearly semi-circular with the posterior and lateral margins continuously round.

Though the first two sternites are folded internally forming the hind coxal cavities (*CxC*), a suture (*s*) is visible differentiating, to a certain extent, between the first (*IS*) and the second (*IIS*) sternites.

c. Pleurites

On either side of each apparent abdominal sternite (Figs. 46 and 47), from the third (*III S*) to the sixth (*VI S*) there is a more or less developed and fused plate representing a pleurite (*Pl*). The first apparent pleurite occurs on the third segment and represents the third pleurite which prolongs forward forming an articular region receiving the hind end of the meta-epimeron (Fig. 46, Epm_3). Forbes (1925) considers this articular region, which is slightly more sclerotized, as representing a fused second pleurite (Figs. 46 and 47, *II Pl*) and refers to a sclerotized nodule (Fig. 46, *x*), existing in the confused flour beetle at the end of the meta-pleural ridge, as possibly representing the first pleurite. As Snodgrass (1907) is of the opinion that the coxal processes of the metapleuron is reduced, the view of Forbes seems to be convincing.

The third, fourth and fifth pleurites are much longer than broad, narrowing out posteriorly; thus the fifth is the narrowest and the shortest. The sixth pleurite is much reduced or entirely absent.

Three pairs of processes or nodules (*Pro*) are present on the fifth, sixth and seventh abdominal segments, possibly representing abdominal appendages. The last pair of these processes fit against two concave regions each located in the elytral costal margin, near the apex (Figs. 35, and 36, *c*). The abdomen converges posteriorly with the last apparent segment (Fig. 46) inclined slightly ventrally.

2. Hidden segments

The membrane connecting the eighth abdominal segment to the seventh is so long as to allow the eighth, ninth and tenth segments, together with the genitalia, to be withdrawn into the abdomen. Retractibility is so complete that hardly anything of these structures is apparent during repose (Fig. 46). These segments vary considerably in the two sexes as follows :

a. Male

(1) The eighth segment : Its tergite (Fig. 48 A, *VIII T*) is crescentic with the lateral regions fairly sclertoized (*p*) while the anterior, posterior and median regions are membranous (*Mb*). The sclerotized plate (*p*) is nearly triangular with a round antero-lateral area presenting a slightly more sclerotized and narrow portion (*a*) near the inner margin. The posterior margin of this tergite is round and fringed with setae shortening gradually

towards the sides. The eighth tergite is broader and larger than the eighth sternite (Fig. 48 B, *VIII S*) and the two are connected antero-laterally by a narrow small membrane.

The eighth sternite (Fig. 48 B, *VIII S*) is not completely crescentic because its posterior margin presents two symmetrical posterior projections more densely fringed with setae than the median or lateral sides. The sternal lateral regions (*p*) are fairly sclerotized while the posterior and median regions are membranous (*Mb*). The antero-lateral regions of the sclerotized plate (*p*) prolongs into a short apodeme (*LAp*).

When at rest, the ninth and tenth segments are located within the cavity of the eighth segment.

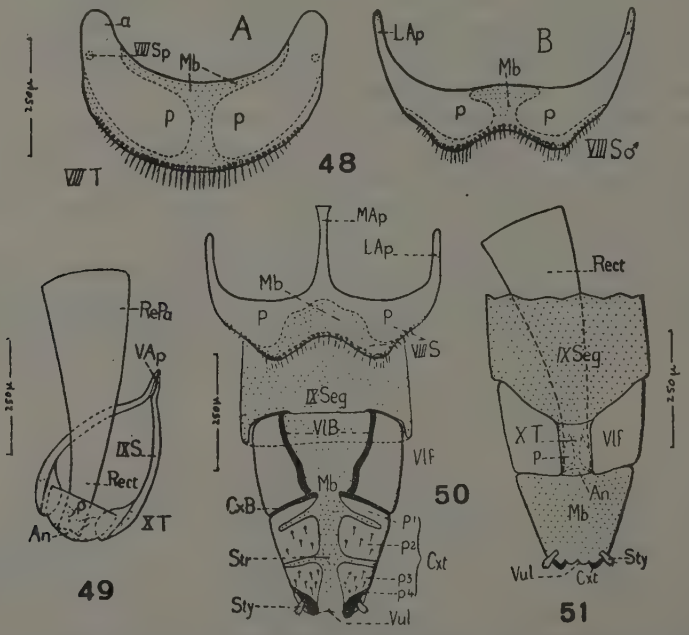


Fig. 48: A, The eighth abdominal tergite, dorsal view; B, The eighth abdominal sternite of the male, ventral view. — Fig. 49: The male ninth sternite and tenth tergite of the abdomen with the rectum, dorsal view. — Fig. 50: The eighth abdominal sternite and the ninth segment of the female together with the female genitalia, ventral view. — Fig. 51: The tenth tergite and the female genitalia with the rectum, dorsal view.

(*a*, heavier sclerotization; *An*, anus; *CxB*, coxital baculus; *Cxt*, coxite with its plates (*P1*, *P2*, *P3*, and *P4*); *LAp*, lateral apodeme; *MAp*, median apodeme; *Mb*, membrane; *p*, sclerotized plate; *RePa*, rectal gland; *Rect*, rectum; *S*, sternite (Roman numbers refer to the numbers of the abdominal segments); *VIII Sp*, eight abdominal spiracle; *IX Seg*, ninth abdominal segment; *Str*, striation; *Sty*, stylus; *T*, tergite (Roman numbers refer to the numbers of the abdominal segments); *VAp*, ventral apodeme; *VIB*, valvifer baculus; *VIf*, valvifer; *Vul*, vulva).

(2) The ninth and tenth segments : Perhaps these two somites, together with the origin of the genitalia, offer a wide field for many different and opposed views by various investigators. This is possibly due to the great reduction or the entire atrophy of the « ninth tergite » and the « tenth sternite » or to their being completely membranous while their still-existing « ninth sternite » and « tenth tergite » are indirectly connected together; thus appear at first glance to represent a single segment considered incorrectly as the « ninth segment » by some investigators as Balfour-Browne (1932) in *Dytiscus*, and Potter (1935) in *Rhizopertha*. Crampton (1920 and 1925), and Snodgrass (1935) agree on the reduction or complete atrophy of the ninth tergite and the tenth sternite, a view which is upheld in this paper.

(a) The ninth segment is present in the feature of a reversed V-shaped structure, representing only its sternite (Fig. 49, *IXS*) and is greatly associated with the male genitalia hence called the « male subgenital plate » (Snodgrass). The sclerotized arms are directed postero-dorsally, arching outwards with their broader and roughly spoon-like posterior ends located lateral to the male genitalia and possessing distributed setae. Though the arms seem to meet anteriorly, forming the short ventral apodeme (*VAp*) of Snodgrass, their duality is still marked off by a less sclerotized area connecting their anterior ends.

(b) The tenth segment (Fig. 49) is present in the feature of a small semi-circular structure representing only its tergite (*Xt*). This latter is membranous except of two small and fairly sclerotized triangular plates (*p*) located mid-dorsally. Its lateral regions connect with the broader posterior ends of the ninth sternite (*IX S*). The anal aperture (*An*) opens just under its posterior margin which bears some short setae.

The tenth sternite is atrophied but Sharp and Muir (1912) consider the membrane separating the anus from the male genitalia as representing the tenth sternite. This membrane is very small in the confused flour beetle and is continuous with the membrane ensheathing the male genitalia.

b. Female

(1) The eighth segment : Its tergite is similar to that of the male (Fig. 48 A, *VIII T*), while its sternite (Fig. 50, *VIII S*) differs by presenting an extra median apodeme (*MAp*) arsing from its anterior margin and directing forwards, giving the sternite, together with the lateral apodemes (*LAp*) a w-shaped aspect.

(a) The ninth segment (Fig. 50 and 51, *IX Seg*) is represented, according to Tanner (1927), by the membrane located between the eighth segment and the ovipositor. This membrane is well developed in the confused flour beetle.

(b) The tenth tergite is represented by a membranous flap (Fig. 51, *XT*) connected dorsally to the ovipositor and possessing two lateral and fairly sclerotized plates (*p*). The anal aperture (*An*) opens at the posterior margin of this flap.

The tenth sternite is not present, but the dim striation (Fig. 50, *Str*) located ventrally on the floor of the vulva, may represent, according to Potter (1935), the tenth sternite.

3. Genitalia

The genitalia of the two sexes are retractile and completely concealed at rest. They are very important in the determination of the species.

a. Male genitalia

Sharp and Muir (1912) who made a comparative study of the male genitalia in Coleoptera, are of the opinion that they develop as an invagination and sclerotization of the membrane between the ninth and the tenth abdominal segments and that no part of any segment enters into the composition of the aedeagus. This view is accepted by recent investigators and, therefore, will be followed in this paper.

The male genitalia (Figs. 52 and 53) of the confused flour beetle is represented by the aedeagus located dorsal to the ninth sternite and composed of :

(1) The median lobe (*ML*) is well developed and is quite distinct from the tegmen ventrally. It is tubular with the median orifice (*MO*) located at its distal extremity and the median foramen (*MF*) at its basal end. The median lobe exhibits two anterior struts (*MS*) ; between their posterior ends the median foramen (*MF*) exists serving for the entry of the ejaculatory duct. The median struts taper anteriorly and their front ends approach. The part of the ejaculatory duct located inside the median lobe, between the median orifice and the median foramen, is called « the internal sac » which is neither visible nor reversible in the confused flour beetle due to the sclerotization of the median lobe. This sclerotization exists from tip to base but is stronger ventrally and laterally but much less so postero-dorsally. The median lobe arches slightly upwards and is protected from the dorsal and the lateral sides by the tegmen to which it is connected by the « first connecting membrane ».

(2) The tegmen (*Tg*) is divisible into :

(a) The basal lobe (*BL*) represents the larger anterior portion of the tegmen, possesing the feature of an incomplete annular structure slightly sclerotized postero-laterally. Its anterior portion is round arching considerably downwards.

(b) The lateral lobes (*LL*) are completely fused together so that their primitive duality is obliterated, being only demarked by a very dim but more pigmented line (*du*) apparent medially. They are pointed posteriorly and their dorsal surface, though continuous with that of the basal lobe dorsally, is demarked (*s*) by being more sclerotized. The lateral lobe shelter the distal portion of the median lobe.

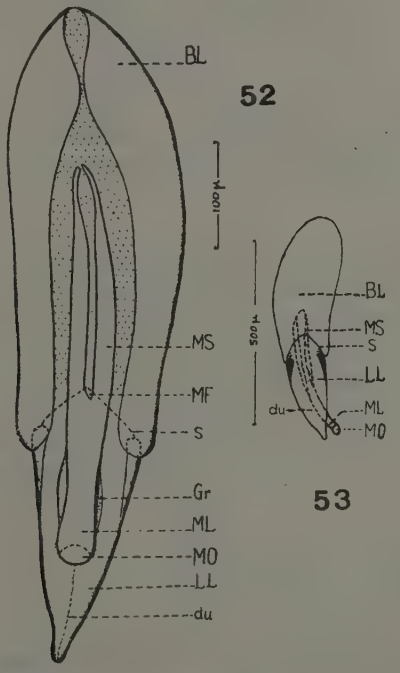


Fig. 52: The male genitalia, ventral view. — Fig. 53: Same, dorsal view, with the median lobe somewhat protruded.

(*Bl*, basal lobe; *du*, heavier pigmentation representing the duality of the lateral lobes; *Gr*, groove; *LL*, lateral lobe; *MF*, median foramen; *ML*, middle lobe; *MO*, median orifice; *MS*, median strut; *s*, suture or limit between (*BL* and *LL*)).

The aedeagus is ensheathed by a membrane representing the « second connecting membrane » (not shown in the Figs. 52 and 53) connecting it with the last abdominal segments. It follows the « Tenebrionid type » illustrated by Sharp and Muir and, as the tegmen is divisible into two parts, it represents also the « trilobe type » recorded by these investigators.

Concerning its position and orientation, the aedeagus lies below the hind portion of the rectum and dorsal to the ninth sternite, the posterior broader ends of which border it laterally. Between these latter regions and

the ventral wall of the rectum, the aedeagus moves freely or protrudes during copulation. When at rest, it is inclined somewhat on the left side and, accordingly, the ejaculatory duct enters it from the right side. The aedeagus is convex dorsally. When almost fully protruded during coition or even by strong pressure, it is completely upset as its posterior end becomes anterior while its dorsal convex surface becomes ventral.

b. Female genitalia

In beetles, the appendages of the eighth and tenth segments disappear while those of the ninth segment persist forming the ovipositor (Tanner, 1927). These genital appendages of the ninth segment, as illustrated by Tanner, are the coxites and the styli while the valvifers are considered as the sclerotized portion of the adjacent end of ninth sternite.

Accordingly, the female genitalia (Figs. 50 and 51) of the confused flour beetle consists of :

(1) The valvifers occupy the antero-lateral regions of the ovipositor and are visible ventrally (Fig. 50, *Vlf*) and dorsally (Fig. 51, *Vlf*). They are connected ventrally by a median membrane (Fig. 50, *Mb*) while the flap representing the tenth tergite (Fig. 51, *XT*) connects them dorsally. Each valvifer presents along its inner ventral limit a much sclerotized rod, the « valvifer baculus » (Fig. 50, *VlB*) of Tanner. The two valvifer baculi diverge anteriorly and may arch slightly inwards in their posterior portions.

(2) The coxites (Fig. 50, *Cxt*) are represented by two sclerotized areas occupying the posterior ventral region of the ovipositor. They are connected mid-ventrally by a membranous region exhibiting dim striation (*Str*), possibly the tenth sternite of Potter (1935), while their corresponding dorsal area is entirely membranous (Fig. 51).

Each coxite is secondarily divided into four plates (Fig. 50, *p1*, *p2*, *p3*, and *p4*), the anterior three of which are fairly sclerotized separated by transverse membranous stripes while the triangular fourth one (*p4*) is strongly sclerotized. The female genital aperture or « vulva » (*Vul*) opens between the two posterior plates (*p4*) of the coxite. The anterior coxital plate (*pl*) is the narrowest and is bordered anteriorly by a sclerotized transverse rod, the « coxital baculus » (*CxB*), which articulates by its mesal portion with the hind end of the similar valvifer baculus (*VlB*). The four baculi are visible ventrally (Fig. 50) forming a framework for strengthening the ovipositor. Short setae are distributed on the coxital plates except the posterior ones.

The anal aperture (Fig. 51, *An*), owing to its location dorsally between the mesal posterior ends of the valvifers, lies in front of the vulva (*Vul*) at a distance equal to the length of the coxites, at the posterior end of which the vulva opens.

(3) The styli (Figs. 50 and 51, *Sty*) are palpi-like structures born dorsal to the fourth coxital plate (Fig. 50, *p4*) and directed postero-laterally. Each stylus is slightly broader distally where it bears frequently three setae.

When at rest, the ovipositor lies within the cavity of the eighth segment within which the membranous ninth segment is infolded ensheathing the ovipositor. The latter answers to the « Tenebrionid type », illustrated by Tanner (1927), for it possesses small styli with secondarily divided and fairly sclerotized coxites which become harder distally.

E. Vestiture of the body

The common body vestitures are pits, nearly circular or slightly oval with small setae arising from their centres, one for each pit. Concerning this pattern of vestiture, the body of the confused flour beetle presents any one of the three cases following :

(1) Certain regions of the body have neither setae nor pits. In the head, the gula (Figs. 3 and 4, *Gu*), the pregula (*Pgu*), the postocciput (Figs. 2, 4, and 5, *Poc*), the posterior regions of both the occiput (Figs. 2, and 4, *Oc*) and the postgenae (Figs. 4 and 5, *Pge*) and the front region of the postclypeus (Figs. 2, 3 and 5, *Pclp*) are all devoid of pits with setae. The posterior region of the prothoracic episternum (Fig. 22, *Eps*), the mesothoracic pre-episternum (Fig. 26, *Prep*) and presternum (Fig. 28, *Prs*), the entire metanotum, the outer region of the metapleuron and the whole abdominal tergites (except the posterior region of the seventh one) all lack pits with setae.

(2) Certain regions of the body have setae devoid of the common pits. The mesothoracic anterior regions of the scutellum (Fig. 24, *Scl*), the episternum (Fig. 26, *Eps*) and the basisternum (Fig. 28, *Bs*) together with the posterior region of the seventh abdominal tergite (Fig. 46), all possess setae without the common pits. The ventral margins of the anterior and the posterior prothoracic foramens have long and dense setae not presented by their dorsal margins. At the base of the metathoracic basalare (Fig. 31, *Ba*) there are frequently seven long setae (differentiated by their length from the other setae in their neighbourhood) often arranged in two rows. The abdominal pleurites present very fine hairs. Legs have also distributed setae.

(3) The other regions of the body present the common pits with central setae. These pits are denser on the frons and parietals (Fig. 1) than on the anterior regions of the occiput and the postgenae where they become gradually smaller backwards. The prothoracic notal pits (Fig. 1) are denser on the lateral than on the median regions, but are much less so, though slightly larger, on the propleura and the prosternum. Pits are larger on the major postero-lateral regions of the mesothoracic scutum (Fig. 24, *Sct*) but

rare on the scutellum while also larger on the meso-pleura and the inner portions of the metapleura. Pits of the meso- and the metasternum and of the abdominal sternites are comparatively larger but denser laterally than medially.

Elytral pits are smaller and somewhat elongated except on the apical disk (Fig. 1) where they become larger and circular.

F. Internal anatomy

1. Repugnatorial glands

According to Walde (1921), the repugnatorial glands in Coleoptera often occur (with much variation in position, form and function) as pouch-like hypodermal invaginations of the cuticle. They contain odorous defensive fluid emitted when desired. Though originally external (integumental derivatives) the repugnatorial glands in the confused flour beetle are dealt with as internal organs because dissection is needed for their fully identification.

Two pairs of such glands are in evidence in both sexes of the confused flour beetle: one prothoracic and the other abdominal. Each prothoracic gland (Fig. 22, *RepG*, dotted) is located in the antero-lateral region of the prothoracic cavity. Its site may be evidenced externally (especially in macerated specimens) by being apparently more reddish-brown than the neighbouring surfaces. It is attached to the anterior prothoracic margin where it opens.

Each abdominal gland (Fig. 47, *RepG*, dotted) is larger than the prothoracic one and is located on one side of the posterior portion of the rectum. It assumes a pear-like shape, narrowing out proximally and opening on the lateral margin of the seventh abdominal sternite (*VII S*), just posterior to its lateral process (*Pro*). In macerated specimens, the abdominal gland could be differentiated (by its reddish-brown colour) through the pale last tergite. The prothoracic and abdominal glands contain reddish oily fluid.

2. Alimentary canal

The alimentary canal (Figs. 54 and 55) of the confused flour beetle is composed of :

(1) The stomodaeum, consists of the buccal cavity, the pharynx, the oesophagus and the proventriculus or gizzard. The buccal cavity (Fig. 54, *Buc*) is the space located immediately behind the true mouth (*Mth*) and guarded on either side by a triangular fairly sclerotized plate (*p*). Pradhan (1940) considers the position of the frontal ganglion as marking the posterior end of the buccal cavity. The pharynx (*Phy*) follows the latter posteriorly and is differentiated from the succeeding oesophagus (*Oe*) by being slightly broader and by its location anterior to the nerve connectives (Snodgrass).

The oesophagus (*Oe*) leads directly to the gizzard (*Pvent*) before which it slightly broadens, representing possibly a reduced crop (*Cr*).

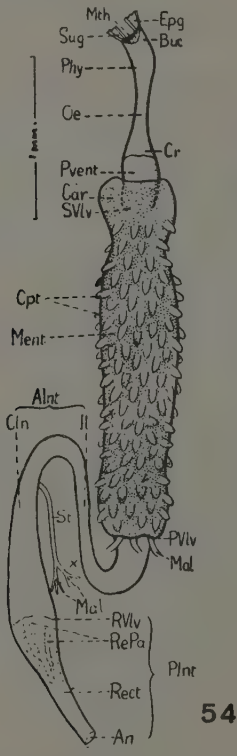
The gizzard (*Pvent*) is a prominent dilated portion at the caudal end of the stomodaeum. It is broader than the oesophagus from which it is differentiated by possessing sclerotized rods internally. It is retracted posteriorly in the mesenteron (*Ment*) forming the cardia (*Car*). When fully stretched, it is differentiated, due to variation in sclerotization, into an anterior and a posterior portions (obvious in cleared specimens) of which the former has denser sclerotized rods. James Beal (1927) is of the opinion that the gizzard and its sclerotized apparatus have considerable value in taxonomy.

(2) The mesenteron begins with the cardia (*Car*) which surrounds the stomodaeal or cardiac valve (*SVlv*). The cardia is followed by a constricted portion behind which the major mesenteron (*Ment*) continues backwards to the pyloric valve (*PVlv*), constituting the widest and the largest portion of the gut, being nearly three times as long as the stomodaeum. It extends from the gizzard anteriorly (near the neck region) and ends posteriorly near the posterior limit of the fourth abdominal sternite. Except for the cardia, the whole mesenteron displays many papilla-like structures (*Cpt*), the crypts of Snodgrass (1935) and Wigglesworth (1942), distributed all over its entire external surface.

(3) The proctodaeum consists, according to Snodgrass, of the anterior intestine (*AInt*) represented by the ileum (*Il*) and the colon (*Cln*), and of the posterior intestine (*PInt*) represented by the rectum (*Rect*). The pyloric valve (*PVlv*) occurs at the meeting of the mesenteron and the anterior intestine. The latter, after extending a short distance posterior to the pyloric valve, turns to the left side and then directs anteriorly parallel to the posterior one-third portion of the mesenteron. This portion of the anterior intestine represents the ileum (*Il*). The latter turns to the left and ventral side and directs posteriorly parallel also to the hind portion of the mesenteron, forming the colon (*Cln*). Consequently, the hind portion of the mesenteron, together with the ascending ileum and the descending colon form a loop or siphon-like structure extending in the third and fourth abdominal segments. The ileum is narrower than the colon which broadens a little posteriorly especially near the rectal valve (*RVlv*).

The posterior intestine or rectum (*PInt*) is broader anteriorly where the rectal valve (*RVlv*) exists at the meeting of the rectum with the colon. It narrows out posteriorly to end by the anus (*An*) which opens just underneath the posterior margin of the abdominal tenth tergite (Figs. 49 and 51). The rectum exhibits six equally spaced pigmented pads (Fig. 54, *RePa*) demarking the rectal glands.

The Malpighian tubes : The confused flour beetle has six long Malpighian tubes (Fig. 55, *Mal*) which empty into the alimentary canal at the pyloric valve (Fig. 54, *PVlv*). The distal ends of these tubes are not free in the abdominal cavity but are associated with the colon as will be presently discussed (Fig. 55, A and B).



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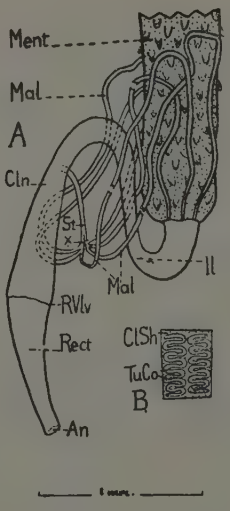

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Fig. 54: The alimentary canal, with the proctodaeum slightly extended. — Fig. 55: *A*, Posterior portion of the midgut and the whole proctodaeum with the Malpighian tubes; *B*, Arrangement of the distal portions of the Malpighian tubes in the wall of the colon.

(*AInt*, anterior intestine or stomodaeum; *An*, anus; *Buc*, wall of the buccal cavity; *Car*, cardia;; *Cln*, colon; *ClSh*, external sheath of the colon; *Cpt*, crypts or papillae of the mesenteron; *Cr*, crop; *Epg*, proximal region of the epipharyngeal wall; *Il*, ileum; *Mal*, Malpighian tube; *Mth*, mouth; *Ment*, mesenteron; *Oe*, oesophagus; *Phy*, pharynx; *PInt*, posterior intestine or proctodaeum; *Pvent*, gizzard or proventriculus; *PVlv*, pylorus valve; *Rect*, rectum; *RePa*, rectal gland; *RVlv*, rectal valve; *St*, stem of the Malpighian tubes; *Sug*, proximal region of the hypopharyngeal wall; *SVlv*, stomodeal valve; *TuCo*, distal portions of the Malpighian tubes in the wall of the colon; *x*, short branch of the stem (*St*)).

The colon possesses an external layer (Fig. 55 B, *ClSh*) which, when stretched by dissection presents six zigzaged tubes (*TuCo*), representing the distal attached portions of the Malpighian tubes. These are ensheathed in the wall of the major hind portion of the colon but they unite anteriorly forming only one vessel (Figs. 54 and 55 A, *St*) which issues from the anterior portion of the colon and directs posteriorly between the latter and the ileum. The stem then divides into two very short and finer vessels (*x*), each of which divides in turn into three tubes. The six tubes, thus resulting, are directed anteriorly running in the abdominal and the metathoracic cavities but finally turn backwards to empty at the pyloric valve. They are associated in their main courses with the mesenteron.

The free portions of the Malpighian tubes have a brown or yellowish-brown colour especially proximally and could be seen through the membranous abdominal tergites in fresh or newly macerated specimens.

Glands associated with the alimentary canal : According to Imms (1934) and Snodgrass (1935), the labial glands are wanting or rarely exist in most Coleopterous insects. No labial glands could be detected in the confused flour beetle. But two tubular glands (Fig. 7, *MxG*) are evidenced, each beginning in the antero-lateral region of the prothorax in the feature of a much coiled tube. The gland then enters the head and ends at the outer portion of the process of the maxillary cardo (Fig. 13, *Cdp*), on the internal postgenal ridge (Fig. 7, *Parc*) which supports the maxilla. The gland is a mere tube assuming the same width all over its entire length. As it is associated with the base of the maxilla it may represent a maxillary gland.

3. Reproductive system

The morphology of the internal reproductive organs are, according to Metcalfe (1933), becoming increasingly important for students of taxonomy and phylogeny.

a. Male organs

The male reproductive organs (Fig. 56) consist of :

(1) The testes (*Tes*), which are located anteriorly in the abdominal cavity, each on one side but slightly ventral to the anterior intestine and are maintained in position by the surrounding fat bodies and tracheae. Each testis consists of six free follicles (*TeFo*) suspended like a cluster of grapes at the distal end of the vas deferens (*Vd*). Each follicle is nearly spherical and sessile as no stalk is differentiated ; thus the follicles are crowded together.

(2) The vasa deferentia (*Vd*) pass posteriorly from the testes and are, to a certain extent, convoluted. Proximally, they change their courses for-

wards and before joining the ejaculatory duct (*Dej*) they form the dilatations of the vesciculae seminales (*Vsm*). The latter have a stable and characteristic position on either side of the ejaculatory duct. Their distal portions approach and are located partly ventral to the latter duct to which they join proximally by their broader ends.

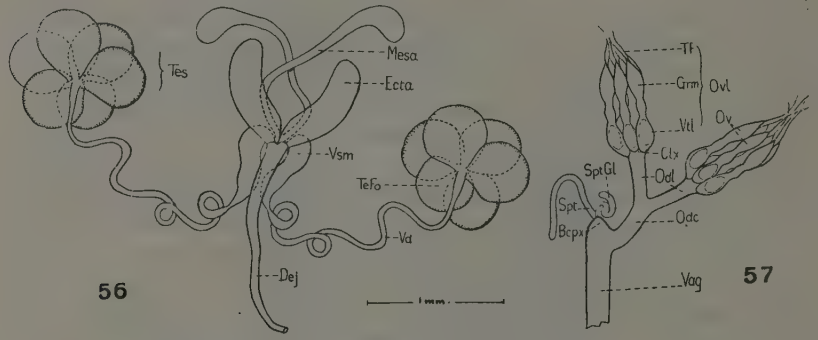

Fig. 56: The male reproductive organs. — Fig. 57: The female reproductive organs. (*Bcpx*, bursa copulatrix; *Clx*, calyx; *Dej*, ejaculatory duct; *Ecta*, ectadenia; *Grm*, germarium; *Mesa*, mesadenia; *Odc*, common oviduct; *Odl*, lateral oviduct; *Ov*, ovary; *Ovl*, ovariole; *Spl*, spermatheca; *SptGl*, spermathecal gland; *Tes*, testis; *TeFo*, testical follicle; *TF*, terminal filament; *Vag*, vagina; *Vd*, vas deferens; *Vsm*, vesicula seminalis; *Vtl*, vitellarium).

The vas deferens (*Vd*) is comparatively long, being about one and a half times as long as the ejaculatory duct. It dilates slightly at its attachment with the testicular follicles.

(3) The ejaculatory duct (*Dej*) is shorter but broader than the vas deferens. It narrows out posteriorly and finally enters the median lobe (Fig. 52, *ML*) of the aedeagus from the right side and through the median foramen (*MF*).

(4) The accessory glands consist of two pairs joining the ejaculatory duct at its anterior end and are divisible, according to Escherich, 1894 (according to Metcalfe, 1933, and Imms, 1934), into :

(a) The mesadenia (Fig. 56, *Mesa*) are two longer, paler and narrower tubes with regarding the ectadenia (*Ecta*). They frequently broaden slightly distally and pour into the anterior end of the ejaculatory duct from the ventral side. They hardly meet proximally and each is twice as long as the ectadenial gland.

(b) The ectadenia (*Ecta*) are broad or rather pouch-like tubes, whiter than the mesadenia. Unlike the latter, they are not convoluted but assume a V-shaped position at the anterior end of the ejaculatory duct. The latter

displays two very slight anterior projections, each receives the ectadenial gland of its side.

b. Female organs

(1) The ovaries (Fig. 57, *Ov*) are located in the anterior region of the abdominal cavity, ventro-lateral to the posterior intestine. Each ovary has four ovarioles; sometimes five or six are in evidence as in Figure 57.

The mature ovariole (*Ovl*) is comparatively long, being about one and a half times as long as the lateral oviduct (*Odl*). It presents three well marked zones, viz : the terminal filament (*Tf*), the germarium (*Grm*) and the vitellarium (*Vtl*); thus following the « meroistic type » (as it possesses nutritive cells) and the « acrotrophic subtype » (as the nutritive cells are located apically without alternating with the oocytes). The ovarioles open proximally into the calyx (*Clx*), a dilatation of the lateral oviduct.

(2) The lateral (*Odl*) and the common (*Odc*) oviducts stand as a y-shaped structure with equal arms and tail. The common oviduct seems to be slightly broader and it opens ventrally in the vagina (*Vag*).

(3) The vagina (*Vag*) is a wider passage, the anterior portion of which extends in front of the aperture of the common oviduct, forming a continuous pouch representing the bursa copulatrix (*Bcpx*) without differentiating limit between the two. The vagina enters posteriorly the ovipositor and the vulva exists at its end. It is one and a half times as wide as the common oviduct.

(4) The spermatheca (*Spt*) and its gland (*SptGl*) open into the bursa copulatrix at its apex. The former is a mere slightly convoluted tube, near the base of which its tubular gland is connected, resembling a reversed s-shaped structure with a kidney-shaped outline. The proximal portion of the gland is slender, opening just very near the spermathecal aperture. Consequently, it is difficult to distinguish if there are two or one common aperture. The coiled gland is yellowish while the spermatheca is paler.

4. Central nervous system

The confused flour beetle has a generalized nervous system (Fig. 58) consisting of the brain, the sub-oesophageal ganglion, three thoracic and eight abdominal ganglia.

The brain (upset in the figure), being well developed, occupies a large area in the centre of the head, with a shallow posterior (*c*) and a deeper anterior (*b*) incisions. The protocerebral lobes (*1Br*) form the main portion of the brain. From their antero-lateral portions, the optic lobes arise, each on one side. The protocerebrum lies naturally postero-dorsal to the deutocerebrum (*2Br*) and the tritocerebrum (*3Br*). These two latter ganglia of

the brain are dimly distinguished from each other or from the protocerebrum. The deutocerebrum (*2Br*) most often appears as two swellings located antero-ventrally, each on one side of the anterior incision (*b*). The tritocerebrum (*3Br*) is not clearly distinguished as it is continuous with the protocerebrum

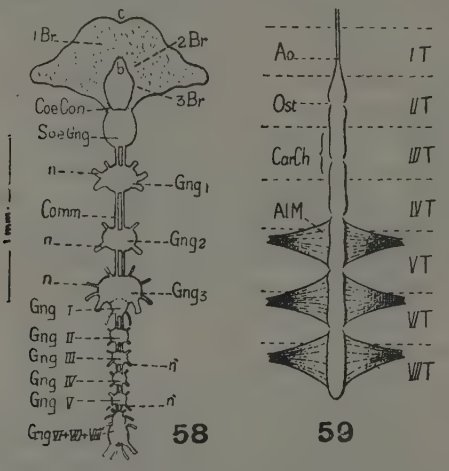

Fig. 58: The central nervous system, with the brain deviated anteriorly (upside down) to show the suboesophageal ganglion. — Fig. 59: The dorsal blood vessel (much enlarged). (*Alm*, alary muscle; *Ao*, aorta; *b*, antero-ventral incision of the brain; *Br*, brain (*1Br*, *2Br* and *3Br*, proto-, deuto-, and tritocerebral ganglia; *c*, postero-dorsal incision of the brain; *CarCh*, a chamber of the heart; *CoeCon*, circumoesophageal (para-oesophageal) connective; *Gng*, ganglion (Arabic numbers refer to the thoracic ganglia while Roman numbers refer to the abdominal ones); *n*, lateral nerve of the thoracic ganglion; *n'*, lateral nerve of the abdominal ganglion; *Ost*, ostium; *SoeGng*, suboesophageal ganglion; *T*, abdominal tergites (Roman numbers refer to the numbers of the segments)).

but is represented by two antero-ventral extensions from which arise the circum-oesophageal connectives (*CoeCon*) of Snodgrass (1935) which connect the brain with the sub-oesophageal ganglion (*SoeGng*). They are short but comparatively thick. The stomodaeum passes through the foramen formed by the brain dorsally, the circum-oesophageal connectives laterally and the sub-oesophageal ganglion ventrally.

The sub-oesophageal ganglion (*SoeGng*) is large, being longer than broad and is bigger than the first thoracic ganglion (*Gng1*).

There are three thoracic ganglia of which the prothoracic (*Gng1*) is larger than the mesothoracic (*Gng2*) while the metathoracic (*Gng3*) is the largest. The former lies near the neck region ventral to the gizzard, and, owing to the retractibility of the head into the prothorax, it lies in the

latter when the head is at rest. The two commissures between the meso- and the metathoracic ganglia are shorter than those between the former and the prothoracic ganglion while those between the latter and the sub-oesophageal ganglion are the shortest of the thoracic commissures. The sub-oesophageal and the thoracic ganglia are much larger than the abdominal ones.

There are eight abdominal ganglia of which the first (*GngI*) is fused with the metathoracic ganglion (*Gng 3*), forming together a pear-shaped structure. The second (*Gng II*), third (*Gng III*), fourth (*Gng IV*) and the fifth (*Gng V*) abdominal ganglia are individually connected by commissures while the sixth, seventh and eighth ganglia unite forming an elongate pear-shaped composite ganglion (*Gng VI + VII + VIII*). The fusion of the last three ganglia into one composite ganglion can, however, be easily detected by the three-segmented appearance of the latter. The posterior segment of the composite ganglion, or actually the fused eighth ganglion, is larger than the anterior two segments combined. The composite ganglion lies between the two lateral oviducts in the female or between the hind ends of the vesiculae seminales in the male.

The length of the commissures between the second and the third, between the third and the fourth and between the latter and the fifth abdominal ganglia are nearly equal and each commissure of them is longer than that located between the fifth and the composite ganglion. The commissures between the first and the second abdominal ganglia are the longest though still shorter than those between the meso- and metathoracic ganglia.

From each of the thoracic or abdominal ganglia, there arise lateral nerves which are larger in the thoracic (*n*) than in the abdominal (*n'*) ganglia. Numerous lateral and posterior nerves arise from the terminal composite abdominal ganglion.

5. Circulatory system

The circulatory system (Fig. 59) includes :

(1) The heart, which in the confused flour beetle, is confined to the abdomen, extending underneath the mid-ventral region between the seventh (*VII T*) and the second (*II T*) abdominal tergites. It is maintained in position by the alary muscles (*AlM*) attached to these tergites. The heart presents five chambers (*CarCh*) well differentiated by the five pairs of ostia (*Ost*), one pair for each chamber. The abdominal tergites from the second (*II T*) to the sixth (*VI T*) each overlaps a chamber, the two ostia of which occur near the middle region of the chamber (Snodgrass). The posterior sixth chamber extends posteriorly underneath the mid-ventral region of the seventh tergite (*VII T*).

(2) The aorta (*Ao*) is a narrow tube formed by the prolongation of the anterior cardiac chamber and extending anteriorly to the head. Its course in the thorax or the head could not be followed by the writer.

6. Respiratory system

a. Spiracles

The confused flour beetle possesses ten pairs of spiracles (Fig. 64) : two thoracic representing the mesothoracic (Sp_2) and the metathoracic (Sp_3) spiracles, and eight abdominal (*ISp* to *VIII Sp*) of which the last is vestigial. The prothoracic spiracles entirely degenerate (Snodgrass). The mesothoracic spiracles are comparatively large and well developed (Fig. 60). They are located (Figs. 21, and 64, Sp_2) in the intersegmental membrane adjacent to the lateral region of the pro-epimeron, thus lodging nearer to the prothorax than to the mesothorax. The metathoracic spiracles are smaller (Fig. 61) than the mesothoracic ones (Fig. 60) and are located in the intersegmental membrane connecting the meso- and the metapleura.

The first abdominal spiracle (Fig. 31, and Fig. 64, *ISp*) is the largest of the abdominal spiracles of which the second, third, fourth, fifth and sixth (Fig. 45, *Sp*) are nearly equidistant and similar in size, while the

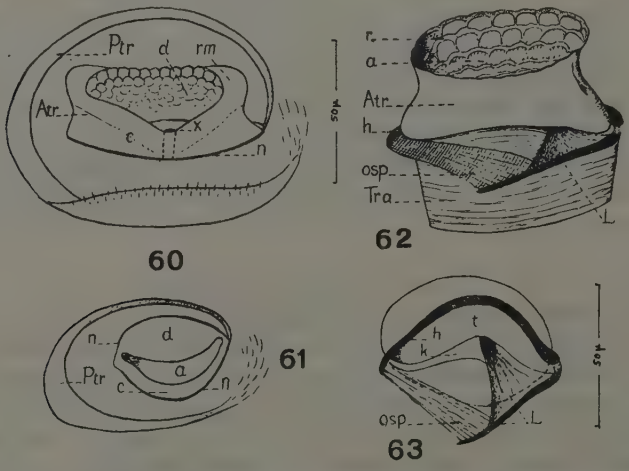

Fig. 60: The mesothoracic spiracle, external view. — Fig. 61: The metathoracic spiracle, external view. — Fig. 62: Type of an abdominal spiracle (much enlarged). — Fig. 63: The closing apparatus of the first abdominal spiracle, internal view.

(*a*, atrial opening; *Atr*, atrium; *c*, posterior lip; *d*, anterior lip; *h*, bow; *k*, band or closing valve; *L*, lever; *n*, sclerotization; *osp*, occlusor muscle; *Ptr*, peritreme; *r*, meshwork sclerotization in the inner atrial wall; *rm*, rim; *t*, tracheal aperture; *Tra*, trachea; *x*, sclerotized rod in the mesothoracic spiracle).

seventh (Figs. 45 A and 46, *Sp*) is the smallest. The latter spiracle lies lateral to the basal portion of the lateral apodeme (*Ap*) of the seventh abdominal tergite. The other abdominal spiracles lie each in the lateral region of the corresponding tergite. They occur mesal to the laterotergites (Fig. 46, *Ltg*) in the third, fourth, fifth and sixth tergites.

In each antero-lateral region of the retracted eighth abdominal tergite (Fig. 48A), there is a rudimentary spiracle (*VIII Sp*) the site of which is demarked externally by fair sclerotization liable to be overlooked but is confirmed internally (Fig. 64, *VIII Sp*) by the tracheae connected to it.

The thoracic spiracles vary greatly from the abdominal ones as follows:

(a) The thoracic spiracles (Figs. 60, and 61) are, according to Snodgrass (1935), of the « lip type », the type with an external closing apparatus. Moreover, they are located within distinct spiracular sclerites or peritremes (*Ptr*) of which the abdominal spiracles are devoid.

The mesothoracic peritreme (Fig. 60, *Ptr*) broadens posteriorly where it becomes somewhat elevated but less sclerotized, bearing fine hairs. The mesothoracic spiracle consists of a posterior (*c*) and an anterior (*d*) lips enclosing between them the spiracular atrium (*Atr*). The smaller posterior lip possesses a median internal sclerotized rod (*x*) running vertically and dividing its outer marginal rim (*rm*) into two parts, giving the atrial orifice a triangular-shaped appearance. Internally the tracheal orifice is guarded by fine sclerotized rods (*n*) while the atrial wall is strengthened by a meshwork of sclerotized rods or ridges (Snodgrass) which are stronger near the atrial orifice and bear very fine hairs. The mesothoracic spiracle is slightly constricted allowing for the formation of a conspicuous rim (*rm*) around the atrial orifice.

The metathoracic peritreme (Fig. 61, *Ptr*) broadens postero-laterally and thins out on either side possessing no hairs. The crescentic atrial orifice (*a*) is somewhat oblique with the two lips (*c*, *d*) less elevated than those of the mesothoracic spiracle. The anterior lip (*d*) is broader and the internal ridges strengthening the atrial wall are comparatively reduced running mainly in circles.

(b) The abdominal spiracles (Figs. 62, and 63) are of the « atrial type », the type with an internal closing apparatus. They possess no peritremes as is the case in the thoracic spiracles.

The abdominal spiracular atrium (Fig. 62, *Atr*) is, in general, sack-like with an oval atrial orifice (*a*) and with its wall strengthened internally by a mesh-work of ridges (*r*), except in the first abdominal atrium where the ridges are arranged rather in circles. The number of the « eyes » of

the outer row of the mesh-work ranges between 10 to 14. The ridges become stronger towards the atrial orifice and they bear fine hairs.

The internal closing apparatus guards the tracheal orifice (Fig. 63, *t*) and consists, according to Snodgrass, of :

(1) A sclerotized crescentic bow (Figs. 62, and 63, *h*) extending along the anterior half of the circumference of the tracheal orifice (*t*).

(2) A y-shaped lever (*L*) guarding dorsally the other posterior half of the circumference and a flexible band or closing valve (*k*) guarding it ventrally. The lever is hinged dorsally with the bow.

(3) An occlusor muscle (*osp*) extending between the lever and the ventral end of the bow and is responsible for the closure of the spiracle.

The abdominal spiracles thus vary from the thoracic ones in both position and structure. They may also vary in function for Kitchel and Hoskins (1935) record the opinion expressed by du Buysson (1924-26) that in most Coleoptera the abdominal spiracles are « inspiratory » while the thoracic are « expiratory ».

b. Tracheae

On each side of the confused flour beetle a longitudinal lateral trunk (Fig. 64, *LTra*) connects the spiracular tracheae from the first abdominal spiracle (*ISp*) to the eighth abdominal one (*VIII Sp*). The lateral trunk is doubled between the first abdominal (*I Sp*) and the mesothoracic (Sp_2) spiracles and also anterior to the latter, that is, in the prothorax and the head.

(1) Head tracheation : The head is supplied by a pair of lateral head trunks on each side, one dorsal (*a*) while the other is ventral (*b*) and the two arise by a common base from the mesothoracic spiracle (Sp_2). The two dorsal head trunks (*a*) of both sides unite anteriorly after entering the head forming the dorsal head commissure (*DHCom*) which is differentiated from them by being suddenly finer. The ventral head trunks (*b*) also form a ventral head commissure (*VHCom*) and each of them gives off a lateral branch (*d*) which subdivides, on entering the head, into two finer tracheae. These latter, together with the finer branches given off by both the dorsal and the ventral head commissures, supply by very finer branches the head capsule, the internal head organs, the mouth-parts and the antennae.

(2) Thoracic tracheation : The lateral trunk is doubled in the pro-, the meso- and the metathorax, being formed of the dorsal lateral trunks (*a*, *f*, *i*) and of the ventral lateral trunks (*b*, *g*, *j*) in the three segments respectively. The ventral lateral trunks of each segment are connected by a ventral commissure. The prothoracic ventral commissure ($VCom_1$) arises near the mesothoracic spiracles, extending anterior the fore coxal cavities (CxC_1) and giving off on either side two branches, one (*h*) to the antero-

lateral prothoracic region and another (*n*) to the fore leg. The meso- and metathoracic ventral commissures ($VCom_2$, $VCom_3$) are located one in front and the other behind the middle coxal cavities (CxC_2), each extending on the anterior ental region of the corresponding sternum. The pro-, the meso- and the metathoracic organs are supplied by fine tracheae given off by these doubled lateral trunks and their ventral commissures. The metathorax is extra supplied by dorsal tracheae ($DTra_3$) arising from the metathoracic spiracles (SP_3) and also by large tracheae given off by the first abdominal spiracles (*I Sp*).

Tracheation of the elytron occurs as follows : Fine longitudinal tracheae are visible in the interspaces 1, 2, 6, 8 and 10 (Fig. 35) which all represent principal veins (refer to pages 204 and 205). The two former tracheae (in interspaces 1 and 2) approach at the base of the elytron and run in very close contact at the posterior side of the basal hinge process (*BPr*), proximal to which they unite forming one principal trachea connected to the general elytral trachea (Fig. 64, *o*). The other three tracheae in the interspaces 6, 8, and 10 also unite proximally forming another principal trachea connected to the general elytral trachea (*o*) posterior to the former one. The trachea (*o*) results from the fusion of two tracheae (*k* and *m*) arising from the meso- and the metathoracic spiracles (Sp_2 and Sp_3) respectively. Elytral tracheae are best visible when examined under direct rays of light.

The hind wing receives two fine tracheae (Fig. 64, *k'*, *m'*) one from the metathoracic spiracle (Sp_3) and the other, which is comparatively « much finer », from the first abdominal one (*1 Sp*). Tracheation in the wing membrane is not obvious.

The fore leg receives a trachea (*n*) from the lateral portion of the prothoracic ventral commissure ($VCom_1$). The middle leg receives a trachea (*n'*) which is the tail of a y-shaped trachea, the arms of which arise from the elytral tracheae (*k*, *m*) near the spiracles. The hind leg receives also a trachea (*n''*), which is the tail of a y-shaped trachea the long larger inner arm of which arises from the hind wing trachea (*k'*) near the metathoracic spiracle (Sp_3), while the other outer and comparatively very much finer arm arises from the first abdominal spiracle (sometimes not obvious).

(3) Abdominal tracheation : Besides the unpaired lateral longitudinal trunk (*LTra*) which connects the abdominal spiracles (*I Sp* to *VIII Sp*), there are other branches given off in the neighbourhood of these spiracles. Each abdominal spiracular trachea, except the eighth, gives off a dorsal trachea (*DTra*) which branches immediately into finer branches (its base only is shown in Fig. 64), supplying the dorsal musculature and the dorsal blood vessel. The ventral branch of each abdominal spiracle unites with the

corresponding one of the other side forming a ventral abdominal commissure. The first (*I VCom*) and the second (*II VCom*) abdominal commissures run on the ental hind region of the metasternum while the third, fourth,

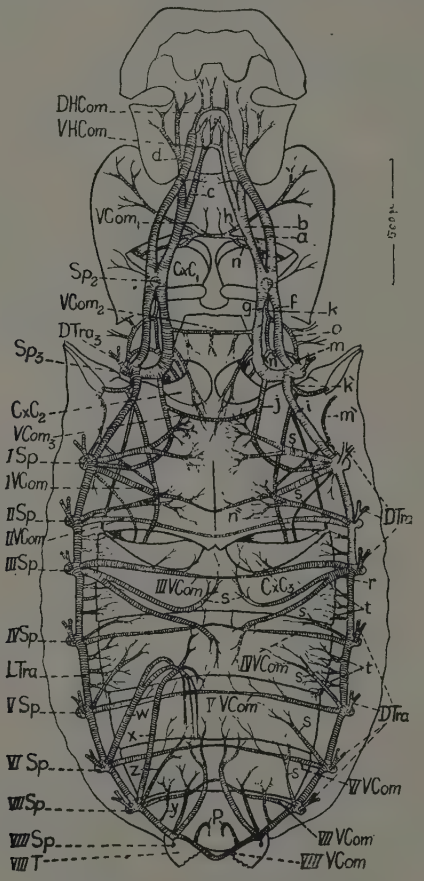

Fig. 64: The tracheal system.

(*Cxc*, coxal cavity; *DHCom*, dorsal head commissure; *DTra*, dorsal trachea; *LTra*, lateral trachea; *Sp*, spiracle; *VCom*, ventral commissure; *VHCom*, ventral head commissure).

Other explanations are best referred to in the text. Arabic numbers for the thoracic structures, Roman numbers for the abdominal ones.

fifth, sixth and seventh abdominal commissures (*III VCom* to *VII VCom*) run each on the ental front region of the corresponding abdominal sternite. The seventh one (*VII VCom*) most often enters the median hind region

of the sixth sternite. The eighth abdominal commissure is the shortest (*VIII VCom*). It stretches underneath the genitalia which is mainly supplied (in the two sexes) by two curled branches (*p*) given off by this commissure.

Other median visceral tracheae (*s*) are given off by the abdominal spiracular tracheae. Those supplying the midgut in the abdomen and the metathorax arise from the first, second and third abdominal spiracular tracheae. The median visceral tracheae (*r*) arise from the third abdominal spiracular tracheae and rebranch immediately after leaving them, supplying finally the hind portion of the midgut. Other fine median tracheae (*s*) are given off by the fourth and the fifth spiracular tracheae and similar fine branches (*t*) arise from the lateral trunks between the second and the fourth spiracles, and all supply the anterior reproductive organs (testes or ovaries).

From the « left » sixth abdominal spiracular trachea (*VI Sp*), a large and long median trachea (*w*) arises, running anteriorly and inwards giving off distally two branches each of which rebranches in turn into three long and finer tracheae. The six latter tracheae run longitudinally along the colon. From the « left » seventh abdominal spiracular trachea (*VII Sp*) two median tracheae (*x* and *z*) are given off and, likewise, run anteriorly and inwards. The longer and larger trachea (*x*) supplies the ileum while the shorter and smaller other one (*z*) supplies the posterior portion of the colon.

Two median visceral tracheae are given off by the eighth spiracular trachea (*VIII Sp*), on each side, the larger of them supplies the rectum and the other supplies the posterior portions of the reproductive organs. The eighth abdominal spiracular trachea is merely connected to the site of the spiracle in the eighth tergite (*VIII T*) by a small strand; as the spiracle itself is vestigial. The lateral trunk between the seventh and the eighth abdominal spiracular tracheae gives off a fine trachea (*y*) supplying the abdominal repugnatorial gland of its side.

G. Sex differentiation

The question of great practical importance for the research workers carrying out experiments with *Tribolium confusum* Duv. is the method by which they could determine the sex of these beetles. As far as it was known, the only reliable external sexual character is found at the end of the abdomen in the « pupal stage » and is illustrated by Park (1934) who is of the opinion that « the pupa is the only stage exhibiting sexual distinction ». Good (1936), agreeing with Park's view, states : « It is on this difference only that the sexes may be distinguished externally, since the appearance of the two sexes in the adult is identical ». Other research

workers such as Dick (1937), Lund and Bushnell (1939) also rely on this feature in differentiating the sexes. The genitalia of the two sexes are concealed by retractibility when at rest and, therefore, are not of considerable value in sex differentiation (externally).

Certain « external » secondary sexual characters can, however, be distinguished in the « adult stage » (not known hitherto) and these are :

(1) The male fore femur presents on its inner surface a circular area with dense fine spurs (Fig. 41 B, *cr*) The female lacks this structure.

(2) The elytral apical disk is wider in the male (Figs. 1, and 36, *ApD*) than in the female (Fig. 35, *ApD*), and this could be evidenced on both the external and the internal sides of the elytron. This character is due to the sexual variation of the distal arrangement of the external carinae or their corresponding internal lines of pigmentation as illustrated on page 204.

(3) The posterior end of the seventh abdominal tergite (Fig. 45, A and B) exhibits, in the male, a sclerotized median posterior projection (Fig. 45 A, *PPr*), not present in the female (Fig. 45 B).

Another « internal » sexual differentiation is exhibited by the eighth abdominal sternite which possesses, in the female (Fig. 50, *VIII S*), a median anterior apodeme (*MAp*) not evidenced in the male (Fig. 48 B).

That the female is slightly larger than the male (Brindly, 1930), is not reliable owing to the variation in the size of the insect.

III. TRIBOLIUM CASTANEUM HERBST

A. Introduction

The apparent similarity of the rust-red flour beetle, *Tribolium castaneum* Herbst (Fig. 65), and the confused flour beetle, *Tribolium confusum* Duv., in size and colour and their likeness in mode of life and habitat mislead investigators of old days making them confuse between the two species considering them as « one ». Good (1936) recorded that Wollaston (1864) took the confused flour beetle to be the male of the rust-red flour beetle. Sharp (1872) was the first to differentiate between the two species by their antennae. Though illustrating some reliable differentiating characters between the two species, Good (1933) recorded « The two species are so similar in size, colour, shape of body and habits that they are continually confused, even by the experienced entomologists ».

After dealing in detail with the morphology of the confused flour beetle it seems advisable to compare between the two species, revealing the differentiating characters not yet known, as those mentioned by previous in-

vestigators are not complete. Sex differentiation of the rust-red flour beetle will also be referred to.

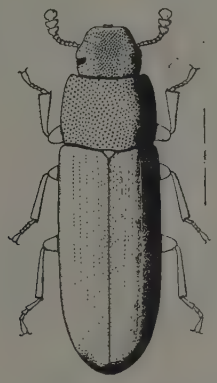

Fig. 65: *Tribolium castaneum* Herbst.

B. Name

The accepted common name for this beetle is the « rust-red flour beetle ». Other names, according to Good (1933 and 1936) are the « ferrugineus » or simply the « red flour beetle ». In Egypt, Willcocks (1925) refers to it as *T. ferrugineum* Fab., a synonymy for *T. castaneum* Herbst.

C. Differentiating characters already known

Tribolium confusum Duv.	*Tribolium castaneum* Herbst
Compound eye	
Both dorsal and ventral lobes connected by a narrow notch (Figs. 2 and 4).	Notch comparatively broad (Figs. 65, 66 and 67).
Both dorsal and ventral lobes comparatively smaller (Figs. 2, 4, and 5).	Both dorsal and ventral lobes comparatively much larger (Figs. 66 and 67).
Dorsal lobe (Fig. 2, *Ed*) strongly margined (*Ema*) by the parietals (*prtl*).	Dorsal lobe not clearly margined (Fig. 67, *Ed*).
Distance between the two ventral lobes (Fig. 5, *Ev*) as two and a half times as wide as the transverse diameter of each ventral lobe.	This distance nearly equal to the diameter of each ventral lobe (Fig. 66, *Ev*) because the latter extends more mesally.
Gena	
The gena (Figs. 2 and 5, *Ge*) projects prominently outwards.	Outward projection of the gena (Fig. 67, *Ge*) not so prominent.

Antenna

The antennal segments enlarge towards the tip (Fig. 17).

Distal antennal segment longitudinally round (Figs. 17 and 18).

The three distal antennal segments enlarge suddenly forming a prominent club (Fig. 68).

Distal antennal segment transversely round (Figs. 68 and 69).

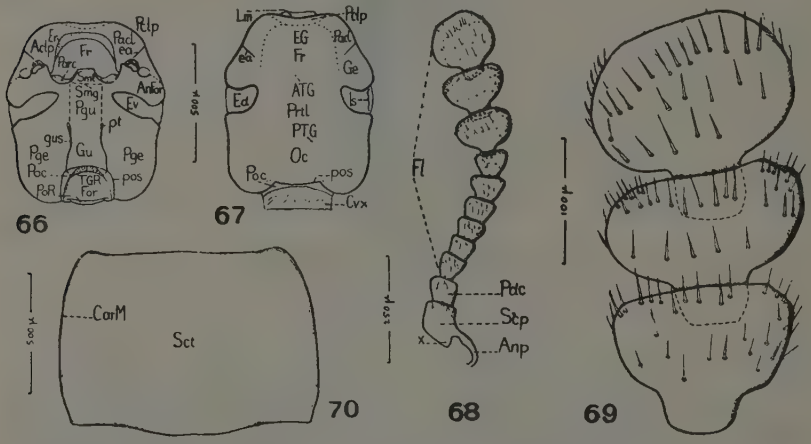

Fig. 66 : The head, ventral view. — Fig. 67: The head, dorsal view. — Fig. 68: The antenna, ventral view. — Fig. 69: The three terminal antennal segments. — Fig. 70: The prothorax, dorsal view.

For explanation refer to Figures 2-7, 17, 18 and 20.

Prothorax

Widest portion of prothorax lies in its front region (Figs 20 and 22).

Antero-lateral angles project prominently anteriorly (Figs. 20 and 22).

Widest portion of prothorax lies in the hind region (Fig. 70).

Antero-lateral angles project very slightly anteriorly (Fig. 70).

Abdomen

Abdominal process (Figs. 46 and 47, *Pro*) somewhat more pronounced.

Abdominal processes less pronounced.

D. Differentiating characters not known hitherto

Some of these characters are external while others are internal.

1. External

Tribolium confusum Duv.

Tribolium castaneum Herbst

Compound eye	
Notch leading to its lobes formed as a result of the caudal extention of the gena and the tendency of the postero-lateral ocular margin to extend anteriorly (Figs. 2, 4, and 5).	Postero-lateral ocular margin never tends to extend anteriorly (Figs. 66, and 67), hence the wider notch results.
Mesal region of its ventral lobe (Fig. 5, *Ev*) broad with a round mesal limit.	Mesal region of this lobe (Fig. 66, *Ev*) not so broad and is pointed mesally.
Gena	
Caudal outer margin of the gena (Figs. 2, 3, 5, and 7, *Ge*) straight or rather concave.	This portion of the margin of the gena obviously round or convex (Figs. 66, and 67, *Ge*).
Head capsule	
Its outline differs from that of the other species. The two transverse grooves (Fig. 2, *ATG*, *PTG*) on the dorsal surface are more obvious.	Neglecting the size of the head, its outline differs, and the two transverse grooves (Fig. 67, *ATG*, *PTG*) are less obvious
Labium	
The membranous area representing the fused glossae (Fig. 14, *Alag*) comparatively wider owing to the presence of a smaller prementum (*Prmt*).	The membranous area representing the fused glossae (Fig. 71, *Alag*) narrower owing to the presence of a comparatively larger prementum (*Prmt*).
Antenna	
Terminal antennal segment not completely round because it is truncated distally (Figs. 17 and 18).	Truncated distal portion not obvious as the margin is nearly round (Figs. 68, and 69).
Pedicel (Fig. 17, *Pdc*) distinctly shorter than the third antennal segment.	Pedicel (Fig. 68, *Pdc*) nearly as long as the third antennal segment.
Basal region of the scape (Fig. 17, *Scp*) round without any tendency of a basal projection.	Basal region of the scape (Fig. 68, *Scp*) truncated and tends to extend or project basally (*x*).
Prothorax	
Posterior portion of its lateral margin concave, forming with the rear margin a more or less right angle (Fig. 20).	Concavity of the similar region not so clear (Fig. 70) and the angle formed is obtuse.
Meso-presternum	
Exhibits a caudal median extention into the basisternum (Fig. 28, *Prs*).	Caudal extention wanting.

Sub-alares

Anterior (Fig. 31, *ASa*) and posterior (*PSa*) subalares clearly detached from each other.

These unite into a single sclerite but differentiation by the varying sclerotization still exists.

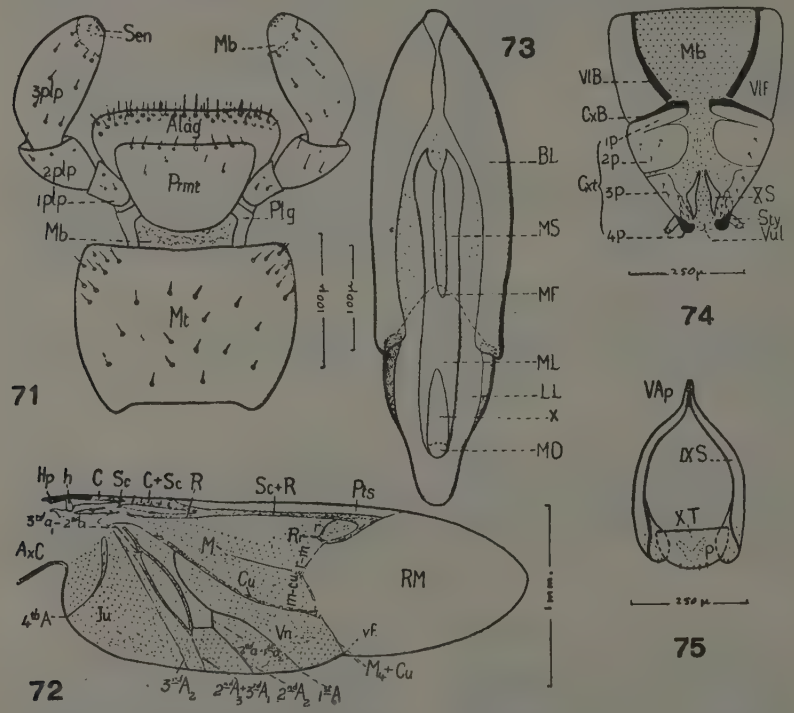

Fig. 71: The mentum and the prelabium, ventral view. — Fig. 72: The hind wing, ventral view. — Fig. 73: The male genitalia, ventral view. — Fig. 74: The female genitalia, ventral view. — Fig. 75: The ninth stemite and the tenth tergite of the abdomen, dorsal view.

For explanation refer to Figures 14, 38, 48-51, 52, 53.

Legs

Circular area with denser spurs on the male fore femur (Fig. 41 B, *cr*) comparatively smaller.

Comparatively wider.

Spurs located on the outer side of the middle tibia (Fig. 42) less in number and the proximal one situated farther from the tibio-femur joint.

These more numerous and the proximal one nearer to the tibio-femur joint (Fig. 65).

Elytron

External carinae or ridges so prominent that their distal arrangement near the apical disk are successful in differentiating the two sexes (Fig. 1).

Carinae smoother, and, therefore, not clear enough to differentiate the two sexes (Fig. 65). (In cleared elytron, sexual differentiation could be done by the elytron as previously mentioned in the other species).

Hind-wing

No setae occur on $C+Sc$ vein (Figs. 38 and 39).

1st A arises from *Cu* with a narrow angle. Accordingly it is comparatively nearer to *Cu* but farther from *2nd A* (Fig. 38).

Cross-vein *1st a - 2nd* a_2 is three times as long as the proximal portion of the *2nd* A_2 before this cross-vein (Fig. 38).

Cross-vein *2nd a - 3rd* a_1 not at all visible as it is concealed by the meeting of *2nd A* and *3rd* A_1. The former vein has an enlarged and more sclerotized portion than the latter.

Some long setae are in evidence on that vein (Fig. 72).

1st A arises from *Cu* with a wider angle, thus being somewhat arched proximally. Accordingly, it becomes comparatively farther from *Cu* but nearer to *2nd A* (Fig. 72).

Cross-vein equal in length to the proximal portion of the *2nd* A_2 before it (Fig. 72).

Cross-vein clearly visible between *2nd A* and *3rd* A_1, and the former vein is similar to the latter both in width and sclerotization near the cross-vein.

Seventh abdominal tergite

Hind median region sclerotized exhibiting a posterior median projection in the male (Fig. 45A, *PPr*). Thus, this tergite is sexually differentiated.

The corresponding region of this tergite is much less sclerotized and is not sexually differentiated.

2. Internal

Tribolium confusum Duv. — *Tribolium castaneum* Herbst

Ninth sternite

Rather V-shaped (Fig. 49, *IXS*).

The arms of this sternite arch more outwards and enclose, therefore, a comparatively wider space anteriorly (Fig. 75, *IXS*).

Male genitalia

Hind end of the fused lateral lobes (Figs. 52, and 53, *LL*) more pointed.

Hind end (Fig. 73, *LL*) less pointed.

Posterior ventral portion of the median lobe (*ML*) does not exhibit any differentiated membranous area.

Median struts (*MS*) taper anteriorly.

Posterior ventral portion of the median lobe (*ML*) exhibits a distinct membranous area (*x*).

Median struts (*MS*) broader anteriorly.

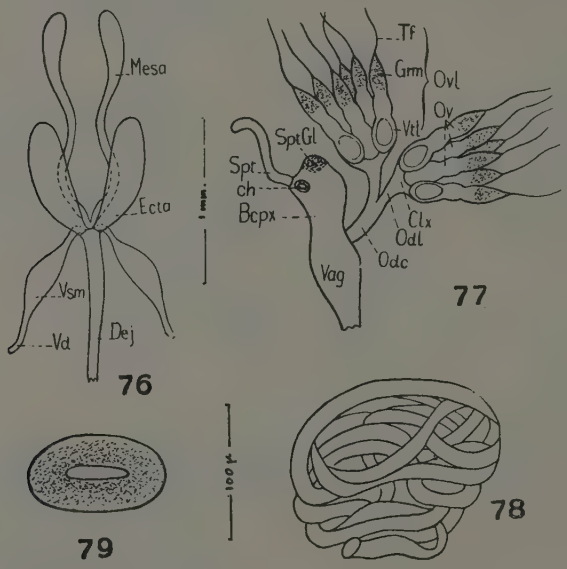

Fig. 76: The main parts of the male reproductive organs. — Fig. 77: The female reproductive organs. — Fig. 78: The spermathecal gland as seen from a cleared specimen. — Fig. 79: The sclerotized structure (Fig. 77, *ch*) as seen from a cleared specimen.

For explanation refer to Figures 56 and 57.

Female genitalia

Tenth sternite represented only by very weak striation (Fig. 50, *Str*) visible ventro-medially between the coxital plates.

Third plate of the coxite (Fig. 50, *p3*) uniformly sclerotized.

Tenth sternite represented by two obvious and fairly sclerotized triangular plates (Fig. 74, *XS*) located between the coxital plates.

Posterior region of third plate (Fig. 74, *3p*) less sclerotized and presenting denser setae.

Internal reproductive organs

Vesiculae seminales (Fig. 56, *Vsm*) comparatively broad proximally. They assume a stable posi-

Vesiculae seminales comparatively narrower proximally (Fig. 76, *Vsm*). Their location on either side

tion on either side of the ejaculatory duct.

Bursa copulatrix (Fig. 57, *Bcpx*) small.

Spermathecal gland free (Fig. 57, *SptGl*).

Wall of the bursa copulatrix does not exhibit any special sclerotized structure.

of the ejaculatory duct varies greatly.

Bursa copulatrix (Fig. 77, *Bcpx*) comparatively much larger and wider.

Spermathecal gland (Fig. 77 *SptGl*, and Fig. 78) not free but is associated with the apex of the bursa copulatrix where it takes the feature of a much convoluted and coiled tube (Fig. 78).

At the entry of the spermatheca (Fig. 77, *Spt*), in the wall of the bursa copulatrix (*Bcpx*), there is a circular sclerotized structure (*ch*). In cleared specimens (Fig. 79) sclerotization occurs in the form of very fine dense rods.

D. Sex differentiation

The inner side of the male fore femur exhibits the circular area with dense spurs and this structure stands as the only reliable character for sex differentiation. As the elytral external ridges are smooth or not sufficiently prominent, the apical disk with the associated ridges could not satisfactorily be sexually distinguished in fresh specimens while in cleared specimens this differentiation is distinct. The seventh abdominal tergite is not sexually differentiated. The female eighth sternite exhibits the anterior median apodeme. not present in the male, but this character is concealed by retractibility.

IV. SUMMARY

(1) Detailed external and internal morphology of the adult confused flour beetle, *Tribolium confusum* Duv. is attempted.

(2) Secondary sexual characters in the adult stage (not known hitherto) are illustrated, concerning both the confused flour beetle (*Tribolium confusum* Duv.), and the rust-red flour beetle (*Tribolium castaneum* Herbst).

(3) Already known and many new characters differentiating between the two species are also enumerated.

V. ACKNOWLEDGMENT

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RESULTS OF THE ARMSTRONG COLLEGE EXPEDITION
TO SIWA OASIS (LIBYAN DESERT), 1935,
UNDER THE LEADERSHIP OF PROF. J. OMER-COOPER

Anaspella antennata n. sp.[1]

[Coleoptera : Mordellidae]

(with 3 Text-Figures)

(22nd Contribution to the study of the Mordellidae)

by Mario Franciscolo, Genoa.

Colore omnino pallide testacea; oculi, nonnumquam abdomen, nigri.

Antennarum articuli IIIus-VIIus subaequales, parvi, praecedentibus sequentibusque valde minores; articuli VIIIus-XIus, abrupte crassiores, clavam formantes, praecedentibus plus duplo latiores, VIIIus-Xus aequales, quam IIIus plus IVus longi. Mas: palporum maxillarium articulus IVus apice intus integro, extus magno sensillo praeditus. Abdomen segmentis quinque integerrimis, appendicibus omnino destitutis.

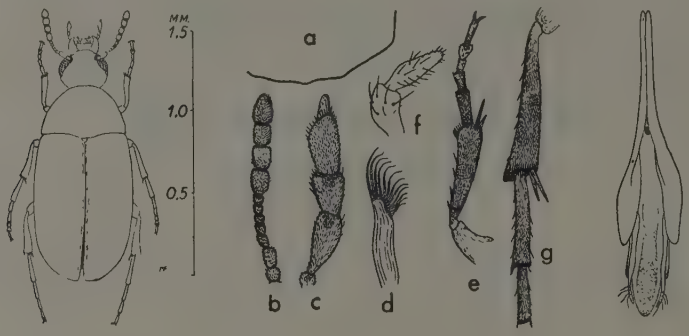
Long. mm. 1.4-1.6; lat. mm. 0.4-0.6.

Body subelliptical, large and dilatate, similar in form to an *Anaspis* (*Larisia*) *Chevrolati* Muls., entirely yellow; eyes black; the abdomen is frequently darker, or entirely black. The elytra are uniformly yellow, without spots or fasciae.

Head subcircular, a little wider than long, with regular transversal series of punctures uniformly distributed on all its surface; the pubescence is pale, opaque, regularly distributed. Eyes black, occupying more than 1/3 of the total width of the head, very coarsely granulated and glabrous. Labrum subtrapezoidal, with 10-16 small teeth on its front margin. Labial palpi (fig. 2f) with last joint subpyriform, dilatate at its middle, and abruptly cons-

(1) This species has been examined by Dr. Blair and given by him the manuscript name of *Pentaria antennata* i.l.

tricted towards the apex. Maxillae brown, with two teeth at their inner side. Galeae (fig. 2d) as long as the maxillae, with 10-12 pectinate appendages at their apex. Maxillary palpi (fig. 2c) with the second joint subpyriform, twice and 1/3 as long as wide; third a little longer than wide, fourth subsecuriform, twice as long as wide, bearing at its outer apical corner a very long sensillum.



1 2 3

Fig. 1: *Anaspella antennata* nov. spec. — Fig. 2: *a*. Mesosternal carina; *b*. Antenna; *c*. Maxillary palp; *d*. Galea; *e*. Anterior leg; *f*. Labial palp; *g*. Hind leg. — Fig. 3: Aedeagus.

Antennae (fig. 2b) short, reaching, when withdrawn, only the half of the pronotum; as regards the proportions of each joint, see the figure. The main feature is given by the presence of a club, which is formed by the four last segments; the basal segments 3rd to 7th are extremely small and short, while the first and second are wider and longer.

Pronotum two-thirds wider at the base than the median length, uniformly and densely covered with close and thin pubescence, with very little sculpture, much wider than the head, but narrower than the base of the elytra.

Scutellum vesy small, subtriangular, rounded at tip.

Elytra one and 2/3 times as long as their basal width taken together, very finely and transversely reticulated, rounded together at the apex, with short and decumbent pale and opaque pubescence; epipleurae very short and thin, reaching only the base of the first abdominal sternite.

Mesosternal carina widely obtuse (fig. 2a), bearing two small prominences on its ventral side.

Fourth segment of the anterior tarsi free, lobate, as long as the third (fig. 2e); hind tibiae as long as the two first segments of the hind tarsi (fig. 2g).

Abdomen of five sternites, without appendages or special hairs; the 5th sternite is regularly rounded at tip, with no differentiated hairs.

Aedeagus as in fig. 3.

Egypt : Siwa Oasis, Armstrong College Expedition, leg. J. Omer-Cooper (British Museum 1935-354), 3 specimens : 19, 21, 27 July 1935 ; 17 specimens : 7, 9, 13, 14, 15, 21, 22, 31 August, 1935.

As far as I know, this is the third species of this genus ; it differs mainly from *Anaspella clavifera* Mars. (*L'Abeille*, XIV, 1876, pp. 25-26) for it is entirely yellow in colour and of a smaller size, the second segment of the antennae longer than the first, and the segments 3 to 7 (instead that 2nd to 7th) small and transverse.

From *Anaspella clavicornis* Schilsky (in Kuster, Käf. Europas, XXXI, 1895, p. 59 ; t. c. XXIV, 1898, p. C.) it differs by its pale yellow colour and by the last joint of maxillary palpi not being sinuate at its apex, bearing a small sensillum at its outer corner.

In the present stage of our knowledge of this genus, the above three spceies may be identified according to the following key :

1 (2) Body entirely black ; 1st segment of the antennae long, filiform, 2nd to 7th short, granulated, subequal, rather narrower and smaller than the first. Long : 2 mm. (Egypt) ..... *clavifera* Mars.

2 (1) Body dark brown or pale yellow ; 1st segment of the antennae about as long as wide, second twice as long as the first, and only the 3rd to 7th narrower and smaller than the second.

3 (4) Body dark brown ; legs dark brown or brown ; last segment of maxillary palpi sinuate at its apex, without sensillum at its outer corner. Long : 1.8-2 mm. (Morocco) ..... *clavicornis* Schils.

4 (3) Body entirely pale yellow : legs yellow ; only the abdomen darker ; last joint of maxillary palpi not sinuate at its apex but bearing a distinct sensillum at its outer corner. Long : 1,4-1,6 mm. (Egypt : Siwa Oasis) ..... *antennata* Franciscolo

Studies on *Tachina larvarum* L. (Diptera, Tachinidae)

I. PRELIMINARY NOTES

(with 1 Text-Figure)

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CONTENTS

Introduction. — Acknowledgments. — Historical review. — Nomenclature. — Original description of *Tachina larvarum*. — Geographical distribution. — Distribution in Egypt. — Host preference. — Host insects in Egypt. — Summary. — References.

INTRODUCTION

The Cotton leaf-worm, *Prodenia litura* F., is one of the most important agricultural pests in Egypt. A study of the factors that influence its population in the field is necessary. These series of papers are an attempt to study one of those factors, the parasite *Tachina larvarum* L., and to determine the role it plays in the control of this pest.

ACKNOWLEDGMENTS

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searches Laboratoy, for assistance, advice and criticism of the work. Due thanks to Professor Dr. H. Priesner for translating the German original description of *Tachina larvarum* into English, to Dr. S. E. Abdul-Nasr, Assistant Professor of Entomology, College of Agriculture, Fouad I University, for reading and criticism of the work, to Mr. A. Alfieri, General Secretray of the Fouad I Entomological Society, for help in collecting the literature, and to M.M. Ibrahim and the staff of the Parasites Laboratory for much assistance in course of the work.

HISTORICAL REVIEW

Although *Tachina larvarum* L. (Fig. 1) was identified and described about two hundred years ago, a detailed study of this parasitic fly has not been made. Aside from taxonomic study and few widely scattered inform-

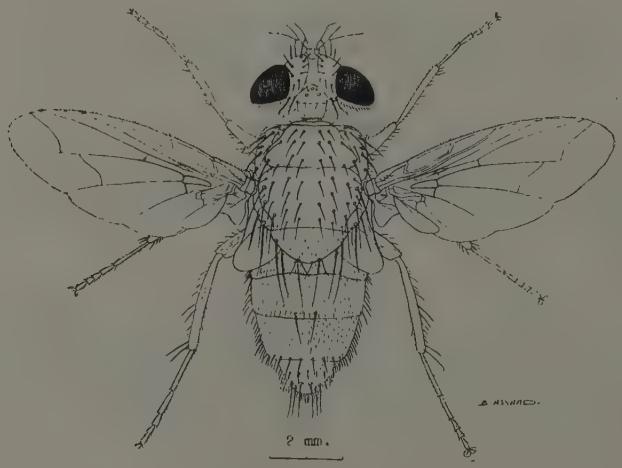

Fig. 1 : *Tachina larvarum* L., adult femaale.

ation concerning host insects and dstribution, the biology of the parasite has been but very poorly studied. Nielson, 1909 and 1913, recorded some few host insects and dealt with some preliminary biological aspects concerning the parasite. In his work on Tachinids, Baer, 1920 and 1921, compiled a good deal of information on the taxonomy and biology of these insects. As for *Tachina larvarum* L., he was mainly interested in recording its hosts which he estimated at not less than fourty-five Lepidoptera and two Hymenoptera. In 1924, Matthey tried to study the biology of what he assumed was the parasite with a special reference to the mode of respira-

tion of the larva and the relation between its respiratory system and that of the host. Unfortunately, the material Matthey used in his work was not *Tachina larvarum*.

In spite of the role it plays in the control of the Cotton leaf-worm, the literature dealing with *Tachina larvarum* in Egypt is comparatively meagre. In his « List of Egyptian insects in the collection of the Ministry of Agriculture », Storey 1916, did not specify *Tachina larvarum* by name. He just stated, after recording four identified species, that there were still twenty unidentified species of the family Tachinidae in the collection. Bishara, 1934, made some biological studies and commented on the efficiency of the parasite in controlling *Prodenia litura* in Egypt. Willcocks, 1937, remarked on the parasite and the role it plays in the control of *Prodenia litura* and expressed the opinion that it might be a very important agent of control. In his remarks, he stated that from 30 to 75 % of the large *Prodenia* larvae were found bearing the conspicuous white eggs of this fly in some fields. Kamal, 1951, recorded some general observations on the life-history of the parasite.

NOMENCLATURE

Owing to the fact that the flies of the family Tachinidae are comparatively large, conspicuous, and everywhere in evidence, they have long ago called the attention of entomologists. The reliable characters now recognised as of real use in differentiating the species of the family as for instance the male terminalia and the chaetotaxy, were wholly overlooked by earlier authors. Several names were thereby given, either by the same author or by different authors, to the same species. *Tachina larvarum*, in common with many other early identified Tachinid species, has thus suffered great instability in its nomenclature, since it was first recorded by Linnaeus in « Systema Naturae », 1758, as *Musca larvarum*. Several authors accepted this interpretation, among which Fabricius, 1786, who defined it as follows : « *Musca* (*larvarum*) : nigricans, scutelli apice subtestaceo ; abdomine tesselato », which means « *Musca larvarum*, blackish, apex of scutum subtestaceous ; abdomen marked with chequer-work ». Meigen, 1803, however, placed the species under the genus *Exorista*. Some recent authors, particularly in the United States of America, still insist on keeping the species under *Exorista* instead of *Tachina* or *Eutachina*. Aldrich, 1931, for instance, in dealing with the species states that it « equals *Exorista* Meigen according to strict rules, as *larvarum* L. was the only species originally included in *Exorista* ». Meigen, 1824, described the species again and for the first time placed it under the genus *Tachina*. Since then various authors described and gave different names to the species. Robineau-

Desvoidy alone recorded 28 specific names under the genus *Tachina* which, according to Bezzi and Stein (1907), turned out all to be synonymies of *larvarum*. Brauer and Bergenstamm (1889) recorded it as *Eutachina larvarum*, but according to the law of priority this name was rejected and was not much used. Aldrich (1931) states : « the genus *Eutachina* has little to stand on as against *Tachina* of authors ».

The confusion in which different authors have fallen is, I believe, due to the inadequacy of adult characters alone as a means of differentiating the different species of Tachinidae. The writer is of the opinion that adult characters alone are not quite satisfactory in identifying the species of Tachinidae at least and that so long as these characters alone are used, there will be plenty of confusion. Thompson (1922), remarked that some species of Tachinidae which were almost impossible to separate as adults, were readily differentiated in the first larval instar and that larval characters show the true affinities between the species of this group better than those of the adults.

The following list is an attempt to trace the synonymies and bibliography of the species :

Musca larvarum Linnaeus, 1758, Syst. Nat., X, 596.
Musca larvarum Scopoli, 1763, Entomologica Carniolica, 331, 888.
Musca larvarum O.F.Mull., 1764, Fauna Friedrichsd., 736.
Musca larvarum L., 1767, Syst. Nat., XII, 992.
Musca larvarum De Geer, 1776, Mem. Ins., VI, 14, 4.
Musca larvarum Shrank, 1781, Enum. Ins., 461, 937.
Musca larvarum Fabricius, 1786, Spec. Ins., II, 442, 34.
Musca larvarum Gmel., 1788, Syst. Nat., V, 2846, 78.
Musca larvarum Rossi, 1790, Faua etr., II, 305, 1503.
Musca larvarum Fabr., 1794, Ent. Syst., IV, 326, 59.
Musca larvarum Cederk., 1798, Faunae ingr. Prodr., 311, 980.
Musca larvarum Shrank, 1803, Fauna boica, III, 119, 2443.
Exorista larvarum Meigen, 1803, Mag. . Insektenk .(Illige), II, 280.
Musca larvarum Fabr., 1805. Syst. Antl., 300, 81.
Musca larvarum Illiger, 1807, Rossi Fauna. etr., II, 467, 1503.
Tachina rustica Fall., 1810, Vet. Acad. Handl., XXXI, 282.
Tachina praepotens Meig., 1824, Mag. f. Insektenk. (Illiger), IV, 292, 95.
Tachina flavescens Meig., 1824, Mag. f. Insektenk. (Illiger), IV, 294, 98.
Tachina larvarum Meig., 1824, Mag. f. Insektenk. (Illiger), IV, 295 ,100.
Tachina rapida Robineau-Desvoidy, 1830, Myod., 187, 1.
Tachina vagans R.-D., 1830, Myod., 187, 2.
Tachina scutellaris R.-D., 1830, Myod., 188, 3.
Tachina rubescens R.-D., 1830, Myod., 188, 4.
Tachina villica R.-D., 1830, Myod., 188, 5.
Tachina macrocera R.-D., 1830, Myod., 188, 6.
Tachina rustica R.-D., 1830, Myod., 189, 7.
Tachina littoralis R.-D., 1830, Myod., 189, 8.
Tachina hispida R.-D., 1830, Myod., 189, 9.

Tachina soror R.-D., 1830, Myod., 191, 17.
Tachina laeta R.-D., 1830, Myod., 193, 22.
Tachina affinis R.-D., 1830, Myod., 193, 23.
Tachina vicina R.-D., 1830, Myod., 193, 24.
Tachina arvensis R.-D., 1830, Myod., 194, 27.
Tachina silvestris R.-D., 1830, Myod., 194, 28.
Tachina larvarum Newman, 1832, Mag. Nat. Hist., V, 252.
Tachina flavescens Macquart, 1834, Soc. Sci. Lille, 1833, 261, 12.
Tachina larvarum Macq., 1834, Soc. Sci. Lille, 1833, 261, 13, t. IV, f. 7.
Tachina rapida Macq., 1835, Suite à Buffon, II, 140, 2.
Tachina macrocera Macq., 1835, Suite à Buffon, II, 141, 4.
Tachina praepotens Macq., 1835, Suite à Buffon, II, 141, 5.
Tachina flavescens Macq., 1835, Suite à Buffon, II, 141, 7.
Tachina larvarum Macq., 1835, Suite à Buffon, II, 141, 8 (t. 14, f. 15).
Tachina arvensis Macq., 1835, Suite à Buffon, II, 142, 10.
Tachina larvarum Hartig, 1838, Jahresb. Fortschr. Forstwiss., I, 282, 9.
Tachina praepotens Meig., 1838, S. B., VII, 190, 1.
Tachina flavescens Meig., 1838, S. B., VII, 190, 2.
Tachina larvarum Meig., 1838, S. B., VII, 190, 19.
Tachina fasciata Meig., 1838, S. B., VII, 191, 7.
Tachina flavescens Siebold, 1838, Wiegm. Arrhiv., IV, 197, 8.
Tachina larvarum Sieb., 1838, Wiegm. Archiv., IV, 198, 10.
Tachina larvarum Zetterstedt, 1838, Ins. Lapp., 634, 2.
Tachina larvarum Blanch., 1840, Hist. Nat. Ins., III, 611.
Tachina fasciata Zett., 1844, Dipt. Scand., III, 1013, 1.
Tachina flavescens Zett., 1844, Dipt. Scand., III, 1014, 2.
Tachina larvarum Zett., 1844, Dipt. Scand., III, 1015, 3.
Tachina macroglossae R.-D., 1850, Annales Soc. Entom. France (2), VIII, 169.
Tachina nigrolineata Walker, 1852, Ins. Brit., II, 85, 150.
Tachina moreti R.-D., 1853, Bull. Soc. Sci. Yonne, VII. 534.
Tachina flavescens Walk., 1853, Ins. Brit., II, 26, 17.
Tachina disjuncta Walk., 1853, Ins. Brit., II, 44, 58.
Tachina praepotens Macq., 1854, Annales Soc. Entom. France (3), II, 375, I (t. 13, f. 1).
Tachina larvarum Macq., 1854, Annales Soc. Entom. France (3), II, 376, 2 (t. 13, f. 2).
Tachina flaviceps Macq., 1854, Annales Soc. Entom. France (3), II, 376, 3 (t. 12, f. 2).
Tachina flavescens Macq., 1854, Annales Soc. Entom. France (3), II, 377, 6 (t 13, f. 4).
Tachina larvarum Rondani, 1859, Dipt. Ital. Prodr., III, 198, 3.
Tachina villica Laboulb, 1861, Annales Soc. Entom. France (4), I, 232.
Tachina larvarum Schiner, 1862, Fauna Austriaca, I, 474.
Tachina villica R.-D., 1863, Posth., I, 958, 2.
Tachina macrocera R.-D., 1863, Posth., I, 959, 1.
Tachina rubescens R.-D., 1863, Posth., I, 961, 3.
Tachina larvarum R.-D., 1863, Posth., I, 962, 4.
Tachina grandis R.-D., 1863, Posth., I, 963, 5.
Tachina littoralis R.-D., 1863, Posth., I, 964, 6.
Tachina hispida R.-D., 1863, Posth., I. 964, 7.
Tachina laeta R.-D., 1863, Posth., I, 965, 8.
Tachina nobilis R.-D., 1863, Posth., I, 965, 9.
Tachina puella R.-D., 1863, Posth., I, 966, 10.
Tachina moreti R.-D., 1863, Posth., I, 966, 11.
Tachina scutellaris R.-D., 1863, Posth., I, 967, 12.

Tachina tardata R.-D., 1863, Posth., 1, 968, 13.
Tachina praepotens R.-D., 1863, Posth., 1, 968, 14.
Tachina melancolica R.-D., 1863, Posth., I, 970, 15.
Tachina festinata R.-D., 1863, Posth., I, 970, 16.
Tachina marginalis R.-D., 1863, Posth., 1, 971, 17.
Tachina delicatula R.-D., 1863, Posth., I, 971, 18.
Tachina larvarum Wulp., 1864, Entom. Tijdschr. (2), IV, 153.
Tachina larvarum Rond., 1865, Atti Soc. Ital. Sci. Nat., VIII, 213, 65.
Tachina praepotens Rond., 1865, Atti Soc. Ital. Sci. Nat., VIII, 214.
Tachina fasciata Bonsd., 1866, Finnl. Insekt., II, 46, 1.
Tachina flavescens Bonsd., 1866, Finnl. Insekt., II, 46, 2.
Tachina larvarum Bonsd., 1866, Finnl. Insekt., II, 47, 3.
Tachina nigrifrons Brischke, 1885, Schrift. naturf. Ges. Danzig, N.F., IV, 18.
Eutachina larvarum Brauer and Bergenstamm, 1899, Denkschr. Akad. Wien., LVI (t. 4, f. 64).
Tricholyga fasciata B. and B., 1891, Denkschr. Akad. Wien., LVIII, 428.
Tachina larvarum Meade, 1892, Entom. Monthly Mag. (2), III, 36.
Chaetotachina flavescens B. and B., 1893, Denkschr. Akad. Wien., LX, 221.
Tachina larvarum Giard, 1894, Bull. Soc. Entom. France, 1894, CLXXX.
Eutachina larvarum Mik. and Wachtl, 1895, Wien. Entom. Zeitg., XIV, 220, 5.
Tachina larvarum Pandellé, 1896, Rev. Entom., XV, 64, 23.
Tachina flavescens Stein, 1900, Entom. Nachricht., XXVI, 137.
Tachina praepotens Stein, 1900, Entom. Nachricht., XXVI, 146.
Tachina larvarum Meij., 1901, Zool. Jahrbuech., XV, 680 (f. 48).

It is to note that Meigen has used two genera for this species (*larvarum*), in example *Exorista* (1803) and *Tachina* (1824). The application of the first generic name, mainly supported by most American authors, is based on the strictest rules of priority. The generic name *Tachina*, on the other hand, is used by most authors, despite the law of priority, in order to avoid the confusion in literature by changing a « so long in use » name. Lundbeck (1927), for instance in his « Diptera Danica » states : « I have kept the name *Tachina*, so long in use, for the present genus, but strictly *Exorista* Meig., 1803, with the type *larvarum* should replace it while *Tachina* should replace *Echinomyia* ».

The writer is of the opinion that *larvarum* should be kept in the genus to save the *Tachina* trouble of confusion which might result from changing a long in use generic name.

ORIGINAL DESCRIPTION OF TACHINA LARVARUM

The following is the English translation of Meigen's original description of the species :

« *Whitish grey, dorsal scutum with four black stripes ; abdomen elliptical with black striae, palpi rust yellow, wing veins not spiny.*

Face silky white ; frons usually straw yellow, both with brown shine ; above the mouth there are some short bristles ; frons in the male narrower

than in the female with deep black stripe; the row of bristles simple, reaching on the face nearly towards the tip of the antennae. Palpi rust yellow, antennae somewhat shorter than the face: third segment brown, somewhat longer than second which is white grey; arista enlarged up to the middle. Dorsum blackish, whitish grey shining with four black stripes. Scutellum blackish, usually somewhat reddish behind. Abdomen elongate, ovate, in the male nearly conical; first segment black, following whitish brown shining with shiny black band at hind margin and at the apex. The sides shine somewhat into cinnabar. Legs black; calyptera white, wings only little grey with a marginal spine: the third longitudinal vein somewhat bristly at its root.

Not rare on flowers and in hedges particularly in summer and in autumn. — 4-5 lin.

This species is very variable in size and colour. The frons is sometimes more white than yellow in the female, the bands of the abdomen are more or less broad.

I do not doubt that this species is really *Musca larvarum* Lin. although his description is much too incomplete to be recognised. Such a common fly, Linnaeus must have received out from caterpillars ».

GEOGRAPHICAL DISTRIBUTION

The family Tachinidae is widely distributed, it is more or less cosmopolitan. *Tachina larvarum* L. is reported mainly from Europe and Western Asia. There are some few records, however, of its occurrence in other countries in Eastern Asia, Africa and Northern America. It is reported to occur in :

Europe : All over the continent, particularly from Czechoslovakia, Denmark, England, Finnland, France, Germany, Hungary, Italy, Yugoslavia, Poland and Russia. It has also been reported from Greenland.

Asia : Astrachan and Caucasus in Russia, Formosa and Japan in the Far-East.

Africa : To the writer's knowledge the only country where the species is reported to occur in Africa is Egypt.

Australia : The species does not seem to occur in Australia or at least does not seem to attack *Prodenia litura* in that continent. In 1940 and 1941 the Parasites Laboratory, Egyptian Ministry of Agriculture, received large numbers of larvae of *Prodenia litura* collected in the vicinity of Brisbane, Queensland, in an attempt to study its parasites in that part of Australia. No *Tachina larvarum* was secured from the material investigated, though two other Tachinid species, *Actia nigritula* and *Tritaxys* spec., were obtained in considerable proportions.

South America : There is no record of the occurrence of *Tachina larvarum* in South America.

North America : *Tachina larvarum* was introduced into the United States from Europe from 1906-1912 and from 1923-1932. It is now well established in that country. In 1945, the fly was recovered for the first time in appreciable numbers from larvae of *Porthetria dispar* collected in the field. Whether this parasite occurred in the United States before its introduction or not, is controversial. Coquillet, 1897, in his « Revision of the Tachinidae of America north of Mexico », does not mention *Tachina larvarum* altogether, but he lists *Tachina mella* and makes no effort to trace its synonymy with *larvarum*. Aldrich, 1931, in his notes on « Francis Walker's types of North American flies of the family Tachinidae », does not record the presence of *Tachina larvarum*. Concerning *Tachina mella*, he states : « The species is a very common northern one and I think identical with *Exorista larvarum* Linnaeus of Europe .... ». Aldrich, 1932, recording the Tachinid flies reared by the late George Dimmock states : « ... pupa only determined by Greene as *Exorista larvarum* Linnaeus (*Tachina mella* Walker) ». He then states : « Coquillet determined the species as *Tachina mella* Walker. It is therefore reasonably certain that the species is what I now call *Exorista larvarum* Linnaeus, ... ». He then records the emergence of one male and five females of *Exorista larvarum*. On the other hand, Allen, 1929, reported the emergence of *Exorista larvarum* from salt marsh caterpillar, *Estigene acraea* and the Arctiid *Apentesis orthona*. Furthermore, *Tachina larvarum* was recorded in 1942 in Connecticut.

The uncertainity among American authors regarding the synonymy of *Tachina larvarum* and its relation to *Tachina mella* is probably responsible for the confusion concerning its status in the United States before its introduction from Europe. Now it is known that *Tachina mella* and *Tachina larvarum* are not synonymies, and that they constitute two different species. This, together with the fact that *Tachina larvarum* was not recorded to attack *Porthetria dispar* L. before its introduction from Europe in spite of the extensive field studies which had been made on this pest, seem to suggest that *Tachina larvarum* did not exist in the United States before its introduction from Europe.

DISTRIBUTION IN EGYPT

The species seems to be well distributed in Egypt. It is recorded from all Provinces of Lower-Egypt and from certain parts of Upper-Egypt (Bishara, 1934).

It was collected by the writer from the following regions :

Lower-Egypt : Alexandria and its vicinity, Dakahlia, Sharkia, Gharbia, Fouadia, Menoufia, Beheira and Kaliubia Provinces, Cairo and its vicinity.

Upper-Egypt : Giza, Beni-Suef, Fayoum, Minia and Assyout Provinces.

The distribution of the parasite in Egypt seems to coincide with the distribution of its main host, *Prodenia litura*. The parasite was not reported from regions south of Assyout where *Prodenia* is not of frequent occurence.

HOST PREFERENCE

The family Tachinidae represents an extensive range in its host preference. It is suggested that there are some Tachinid species which have a much wider host range than is known in any other group of parasitic insects (Clausen, 1940). Not only many orders of insects, but also other groups of the animal kingdom such as scorpions, earth-worms and snails are parasitised by one or more species of the family. *Tachina larvarum*, however, is mainly restricted in its host preference to the order Lepidoptera although some Tenthredinids (Hymenoptera) are also recorded as hosts. *Tachina larvarum* is known for its widely polyphagous habit, about seventy species of insects having been reported as its hosts. They are listed hereunder

Lepidoptera

Pieridae : *Pieris brassicae* L. — Nymphalidae : *Melitaea didyma* O., *Vanessa antiopa* L., *Vanessa io* L., *Vanessa polychlorus* L., *Vanessa urticae* L. — Papilionidae : *Papilio machaon* L. — Sphingidae : *Chaerocampa elpenor* L., *Pterogon proserpina* Pallas, *Deilephila galii* Rott., *Deilephila euphorbiae* L., *Macroglossa stellatarum* L., *Metopsilus porcellus* L. — Geometridae : *Amphidasis cognatria* Gn. — Arctiidae : *Arctia caja* L., *Arctia hebe* L., *Arctia villica* L., *Estigemene acraea* Dru., *Apantesis orthona*, *Diacrisia virginica* F. — Noctuidae : *Agrotis segetum* Schiff., *Agrotis exclamationis* L., *Plusia circumflexa* L., *Plusia gamma* L., *Plusia iota* L., *Mamestra brassicae* L., *Heliothis dipsacea* L., *Acronycta rumicis* L., *Cucullia prenanthis* B., *Catocala fraxini* L., *Orthosia humilis* F., *Panolis griseovariegata* Goeze, *Prodenia litura* F. — Lymantriidae : *Lymantria* (*Porstetria*) *dispar* L., *Lymantria monacha* L., *Euproctis chrysorrhaea* L., *Orgyia postica* Wlk., *Olene mendosa* Hb., *Olene basiflavus* Pack., *Orgyia antiqua* L., *Orgyia gonostigma* F., *Orgyia ericae* Germ., *Pseudodura dasychiroides* Strand, *Stilpnotia salicis* L., *Spilosoma lubricipeda* L., *Porthesia similis* Fuessl., *Ocneria detrita* Esp., *Dasychira fascelina* L. — Notodontidae : *Pygaera anastomosis* L. —

Bombycidae : *Andraca bipunctata*, *Macrothylacia* (*Bombyx*) *rubi* L. — Lasiocampidae : *Lasiocampa quercus* L., *Nadiasa obsoleta* Klug., *Malocosoma neustria* L., *Malocosoma castrensis* L., *Dendrolimus pini* L., *Cosmotriche potatoria* L., *Gastropacha quercifola* L. — Saturniidae : *Saturnia pyri* Schiff., *Hemileuca oliviae* Ckll. — Pyralidae : *Loxostege sticticalis* L. — Eucosmidae : *Olethreutes hercyniana* Tr. — Zygaenidae : *Zygaena filipendulae* L., *Zygaena lonicera* Schw., *Zygaena ephialtes* L. — Yponomeutidae : *Yponomeuta evonymellus* L.

Hymenoptera

Tenthredinidae : *Lophyrus pini* L., *Acantholyda pinivora* Ensl.

HOST INSECTS IN EGYPT

In Egypt *Prodenia litura* F. seems to be the main host of *Tachina larvarum*. Willcocks (1937) stated that the parasite was in fact rare on *Agrotis*, less common on *Laphygma* and very common on *Prodenia*. Bishara (1934) observed that except for a single case where *Tachina larvarum* was noticed to parasitise a Sphingid larva, the only host of the parasite was *Prodenia litura*. Extensive field collections made by the present writer revealed that although *Prodenia litura* was the main host, *Laphygma exigua*, *Plusia gamma*, *Plusia circumflexa*, and *Anadiasa undata* Klug were also fairly attacked. Furthermore, the parasite was not noticed to emerge from the culworm, *Agrotis ypsilon*, which is a regular host of the Tachinids *Gonia capitata* and *Actia palpalis*. When confined in cages, however, the parasite was seen to deposit eggs on *Agrotis* larvae. The eggs hatched in the normal way, but the first instar larvae of the parasite failed to penetrate the host integument and perished in few hours. In the light of these observations and experiments it seems probable that the Tachinids observed by Willcocks to emerge from *Agrotis* larvae were not *Tachina larvarum*, but were probably a closely related species. It seems also probable that under natural conditions *Agrotis* larvae might be attacked by *Tachina larvarum*, but the parasite would perish before penetrating the body of the host.

Tachinids confused with *Tachina larvarum* were observed to emerge from the Sphingids *Acherontia atropos*, *Sphinx convolvuli* and *Daphnis nerii*. Thorough examination, however, proved them to be different species.

It might be of interest to note that *Prodenia litura* is the only species of the genus *Prodenia* which was reported as host of *Tachina larvarum*, and that outside Egypt the pest was not recorded as host of the parasite.

SUMMARY

Tachina larvarum L. is one of the indigenous parasites of the Cotton leaf-worm, *Prodenia litura* F., in Egypt. Very little was known concerning the parasite both in Egypt and abroad. Its synonymies are traced since 1758, and its original description by Meigen (1824) is translated into English. The parasite is well distributed in Europe, in some localities in Asia, in Egypt, and was recently established in U.S.A. In Egypt, it is collected from Lower-Egypt and as far south as Assiut in Upper-Egypt. Sixty-six species of Lepidoptera and one species of Hymenoptera are recorded as its hosts in the world. Its hosts in Egypt are determined.

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Studies on *Tachina larvarum* L. (Diptera, Tachinidae)

E.M.V

II. MORPHOLOGY OF THE ADULT AND OF ITS EARLY STAGES

(with 61 Text-Figures and 3 Tables)

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Introduction. — Laboratory breeding : host rearing, parasite rearing, individual breeding of the parasite. — General morphology of the adult : head, macrochaetae of the head, antennae, proboscis, thorax, thoracic macrochaetae, wings, legs, abdomen, male reproductive system, female reproductive system, male terminalia, phallosome, female terminalia. — Morphology of the early stages : egg, larval stages, puparium. — Summary. — References.

INTRODUCTION

As a contribution to our knowledge of the parasite *Tachina larvarum* L., a study of the morphology of the adult and of its early stages was carried out. Some few information concerning the parasite, mostly dealing with taxonomic studies, hosts and few other aspects, is found in literature. Its morphology, on the other hand, has almost received no previous attention.

LABORATORY BREEDING

In order to make a thorough study of the morphology of the parasite, especially of its early stages, it was found imperative to find out an easy and efficient method of breeding the host, *Prodenia litura*, and the parasite, *Tachina larvarum*.

Host rearing

For breeding *Prodenia litura* in the laboratory, the same host breeding method described by the writer in a previous paper (Hafez, 1947) was used.

Parasite rearing

About five couples of the parasite are confined in a cage similar to those used in host breeding. Honey droplets on a leaf of *Nerium oleander* and several pieces of cotton wool saturated with water are placed in the cage. When female parasites are ready to deposit, about twenty sixth instar *Prodenia* larvae are placed in the cage. Plant sprigs in a water bottle are also placed to provide food for host larvae. After twenty four hours of exposure, parasitised host larvae are transferred to the breeding cages where they are provided with food until the parasites reach the pupal stage. Emergence of adult flies soon follows.

Individual breeding of the parasite

For accurate experimenal studies, individual breeding is also carried side by side with mass breeding. A single couple of the parasite is confined in present writer in breeding *Microplitis demolitor* (Hafez, 1951). As soon as oviposition takes place, each parasitised larva is removed and bred individually in a host breeding unit.

This individual host breeding unit is similar to that described by the present writer in breeding *Microplitis demolitor* (Hafez, 1951). As soon as the parasite puparia are formed, they are transferred and placed singly in small glass vials, 12 × 4 cms. where emergence takes place.

MORPHOLOGY OF THE ADULT

Head

The terminology used in describing the head is after that used by Wainwright (1928). He has, for the main part, adopted the scheme of Robineau-Desvoidy (1830). Whenever it was found desirable he also followed as closely as possible the terms used by Löew (1862).

When the old terms of these two authors seemed undesirable or not available, Wainwright, keeping to tradition as much as possible, proposed some few new terms such as ocellarium, vibrissaria, etc.

The head (Figs. 1, 2, 3 and 4) is rather hemispherical in shape, its anterior surface being comparatively strongly convex with the apex nearly at the lunula, about the bases of the antennae. The posterior surface, on the other hand, is slightly convex with the center towards the occipital foramen.

Table I shows the breadth of the head and its proportion to the length of the body ; and the breadth of the frons and its proportion to the breadth of the head in 15 males and 17 females.

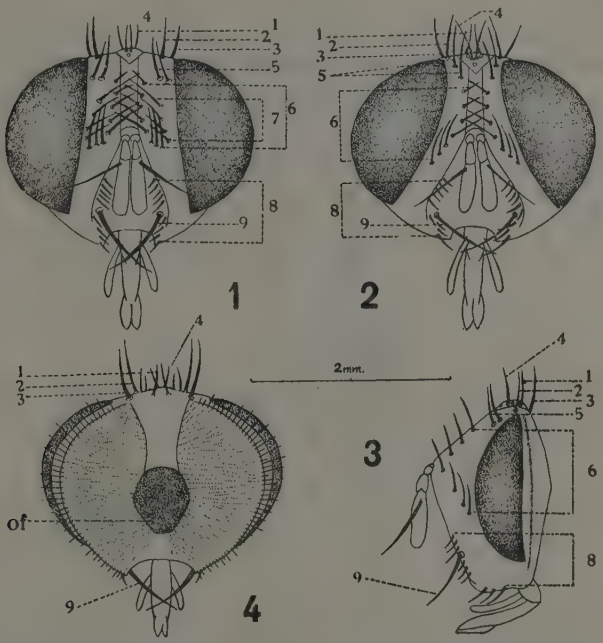

Fig. 1 : Head of female, frontal view. — Fig. 2 : Head of male, frontal view. — Fig 3 : Head of male, side view. — Fig. 4 : Head of male, back view.

1, post-vertical; *2*, inner vertical; *3*, outer vertical; *4*, ocellar; *5*, praevertical; *6*, frontals; *7*, fronto-orbitals; *8*, facials; *9*, vibrissa; *of*, occipital foramen.

It is clear from Table I that : (1) while the average length of the body is 9.4 mm. in males, it is 6.7 mm. in females ; (2) the average breadth of the head (at its broadest part) is 2.865 mm. in males and 2.476 mm. in females ; (3) the proportion of head breadth to body length in percentage is on the average 31.6 in males and 37.3 in females ; (4) the average breadth of the frons (taken across the vertex on a straight line between the two uppermost corners of the compound eyes, this line nearly passes through the two horizontal ocelli or somewhat behind) is 0.873 mm. in males and 0.828 mm. in females ; (5) the proportion of frons breadth to head breadth in percentage is on the average 30.4 in males and 33.5 in females.

These data show very clearly that if a series of measurements of the breadth of the head and the breadth of the frons of female flies were taken

and compared with those of the males, it would be proved that the female head and frons are on the average smaller than those of the males. On the other hand, if the proportion of the width of the head to the length of the

TABLE I

Measurements of body length, head breath and breath of frons in a series of males and females

SEX	INSECT NUMBER	LENGTH OF BODY IN MILLIMETRES	BREATH OF HEAD IN MILLIMETRES	BREATH OF FRONS IN MILLIMETRES	PROPORTION IN PERCENTAGE OF HEAD BREATH TO BODY LENGTH	PROPORTION IN PERCENTAGE OF FRONS BREATH TO HEAD BREATH
Males	1	9.0	2.825	0.900	31.4	31.9
	2	8.5	2.775	0.844	32.6	30.4
	3	8.0	2.675	0.775	33.4	28.9
	4	9.3	2.825	0.825	30.4	29.2
	5	9.7	3.000	1.025	30.9	34.2
	6	9.0	3.100	1.050	34.4	33.9
	7	9.5	3.225	0.920	33.9	28.9
	8	7.2	2.250	0.625	31.3	27.8
	9	7.0	2.125	0.650	30.4	30.6
	10	7.5	2.450	0.750	32.7	30.6
	11	9.5	3.050	1.025	32.1	33.6
	12	10.3	3.200	0.925	31.1	28.9
	13	10.5	3.050	0.950	29.0	31.1
	14	13.0	3.450	1.050	26.5	30.4
	15	12.3	2.975	0.775	24.2	26.1
AVERAGE		9.4	2.865	0.873	31.6	30.4
Females	1	5.5	2.000	0.750	36.4	37.5
	2	7.0	2.575	0.900	36.8	35.0
	3	7.0	2.475	0.800	35.4	32.3
	4	6.0	2.600	0.850	43.3	32.7
	5	6.0	2.275	0.700	37.9	30.8
	6	5.8	2.425	0.800	41.8	33.0
	7	7.2	2.500	0.900	34.7	36.0
	8	8.2	2.775	0.925	33.8	33.3
	9	7.5	2.675	0.750	35.7	28.0
	10	5.5	2.050	0.750	87.3	36.6
	11	7.3	2.575	0.750	35.3	29.1
	12	6.3	2.425	0.850	38.5	35.5
	13	6.3	2.450	0.850	38.9	34.7
	14	5.3	2.075	0.700	39.2	33.7
	15	8.8	3.200	1.100	36.4	34.4
	16	6.3	2.275	0.775	36.1	34.1
	17	7.5	2.750	0.925	36.7	33.6
AVERAGE		6.7	2.476	0.828	37.3	33.5

body was taken, the female proportion would on the average be larger than that of the male. This is due to the fact that males are usually larger in

size than females. The same thing holds true in case of the frons which in proportion to the breadth of the head is wider in females than in males. The statement in literature to the effect that the frons in the males is a little narower than in the females thus hold true only when the breadth of the frons is taken in proportion to the width of the head.

The most prominent part of the head are the two compound eyes which occupy the greater part of its sides. They are dichoptic in both sexes being separated by the frons and the face. The posterior margin of the eye is almost straight while the anterior margin is rather circular. The colour of

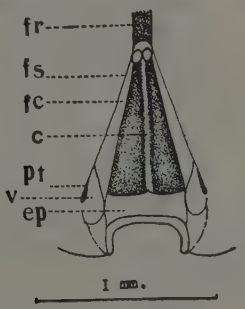

Fig. 5: Face of adult, antennae removed (*c*, carina; *ep*, epistoma; *fc*, fascialia; *fr*, frontalia; *fs*, frontal suture; *pt*, ptilinope; *v*, vibrissaria).

the eyes varies from pale or yellowish brown to dark cinnabar brown. The frons is pupped out and extends from the bases of the antennae to the upper part of the head between the two compound eyes. Three regions are recognised in the frons; the ocellarium occupying the median uppermost area, the frontalia extending longitudinally down the central part and the two frontorbitae lying on both sides of the frontalia. The ocellarium is triangular in outline and is more prominent than the other parts of the frons. It is dark brown in colour with fine dark hairs scattered on its surface. It encloses the three minute hemispherical shining brown ocelli.

The frontalia is a longitudinal stripe which extends from the ocellarium down to the frontal suture. It has a distinct velvet brown colour. In certain cases it may be velvet dark brown or even velvet black. The frontalia lies in a shallow depression and thus the frontorbitae look more prominent on its sides. The frontalia is distitute of any hairs.

The frontorbitae are situated between the anterior margin of the compound eyes and the frontalia. They are clothed in both sexes by fine black hairs which are very dense at the upper parts and gradually become thinner downwards. The colour of the frontorbitae presents a character of great importance in sex differentiation. With the exception of the area around the

ocellarium which is dark in both sexes, the frontorbitae are golden yellow in the male and silvery white in the female.

Lying between the compound eyes and the arms of the frontal suture below the frons are the genae and the medianae. Their colour is silvery-white in the female and metallic white with a pale yellowish hue in the male. These colours correspond to those of the frontorbitae. In both sexes the mediana is a little darker than the gena. The latter region, with the exception of a small area at its upper part which is beset with few scattered hairs, is almost bare. The mediana, however, is densely covered with fine hairs.

The frontal suture lies ventral to the frons, and gives off two arms which extend downward and enclose the face between them.

The face (Fig. 5) is rather triangular in shape and shining silvery in colour. The ridges on both its sides, the facialiae, have also the same colour. At the distal end of each facialia is a callus-like structure which bears the stoutest bristle on the head, the vibrissa, and accordingly termed the vibrissaria. Associated with each vibrissaria at the end of the frontal suture arm is a small pit, the ptilinope. The facial depression is divided longitudinally into two parallel grooves, the antennal foveae, in which the antennae repose. The foveae are separated from each other by a slightly raised longitudinal ridge, the carina.

Extending from the vertex down to the mediana, between the posterior margin of the compound eye and the occipital edge of the head is a narrow stripe, the postorbita. It is metallic light grey or silvery in colour in both sexes. The postorbita is separated from the occiput on each side by a row of stout black bristles which extends downward from a region near the upper end of the compound eyes to the epistoma. These bristles vary in length.

The posterior surface of the head is dark grey in colour. A comparatively large and rather hexagonal occipital foramen occupies a region a little down the center of the occiput. Except for the area between the vertex and the foramen and that between the latter and the epistoma, the surface of the occiput is densely covered with long white hairs.

Macrochaetae of the head

The study of macrochaetae is a subject of great value in the classification of Diptera. The number and position of cephalic bristles are most important in the Tachinidae and present characters of great importance in identification of genera, species and in some cases even sexes of the same species. The following are the cephalic bristles in *Tachina larvarum* L. :

(1) The post-verticals : one pair of comparatively short bristles, situated on the vertical margin, just between the vertex and the occiput, slightly behind the ocellarium.

(2 and 3) The verticals : two pairs of bristles almost situated on the posterior dorsal edge of the head between the frontorbitae and the occiput. These bristles are differentiated into (a) inner verticals (a pair of comparatively large bristles almost situated on the uppermost edge of the frontorbitae, near the edge of the compound eyes) ; (b) outer verticals (a pair of smaller bristles situated a little behind the previous pair and just behind the uppermost corner of the compound eyes).

(4) The ocellars : a pair of bristles situated on the ocellarium, usually diverging outward and slightly downward.

(5) The praeverticals : two pairs of bristles situated at the upper parts of the frontorbitae and directed upwards.

(6) The frontals : two rows of bristles situated on the frontorbitae, one row on each side of the frontalia. The number of bristles in each row is not constant in different individuals or even in different rows in the same individual. Very often there are 7-9 bristles in each row. The row begins one fourth down the frontalia passing in parallel with its edge and extending down to the gena in parallel with the frontal suture until it ends opposite to the proximal end of the third antennal segment. The bristles gradually increase in size downwards. Usually the bristles of the two sides of the frontalia interlock with each other.

(7) The frontorbitals : two rows of bristles which occur in females only and thus present an important secondary sexual character. These bristles are found on the frontorbitae in parallel with the frontals and lie between them and the compound eyes. The frontorbitals are fewer in number than the frontals.

(8) The facials : two rows of short bristles situated on the facialiae just inside the frontal sutures. Each row begins half way along the length of the facialia of its side or a little higher and extends downward to the lower end of the head near the epistoma. The position of these bristles presents an important specific character as they do not ascend so far as to reach the level of the descending frontals in *Tachina larvarum* while they do so in *Tachina fasciata*.

(9) The vibrissae : a pair or long strong bristles situated on the vibrissariae. They are closely associated with the facials, bend inwards and interlock over the epistoma.

Antennae

The antenna (Fig. 6) is aristate in form and brown or greyish in colour. It consists of three segments and an arista on the third segment. The first segment is triangular in shape and about 0.330 mm. in length. On its distal anterior end it carries few comparatively short spines. The second segment

is larger and almost triangular in shape. It measures about 0.380 mm. in length and bears on its anterior surface few big stout macrochaetae together with few short spines on the inside surface of its distal end. The third segment is more or less rectangular in shape. It is comparatively large measuring about 0.830 mm. in length and 0.370 mm. in breadth. It is clothed with very short refractive hairs and bears the arista near its base. The arista is thick at the base and tapers apically to a long thread. It is about 1.25 mm. long and is composed of three segments. The two basal segments are cylin-

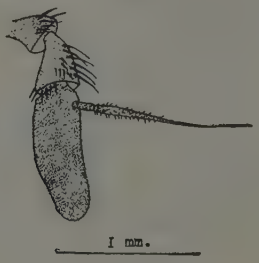

Fig. 6: Antenna.

drical and short and together measure about 0.090 mm. in length, with the first segment about half the length of the second. Both segments are covered with short hairs. The terminal segment is long and tapers to a thread. At least its basal third is covered with short hairs which are comparatively dense at the proximal part and gradually become less dense distally until they completely disappear before the middle of the segment. Thus more than the apical half of the arista is bare.

The position of the antennae, their foveae and other related points were previously discussed.

Proboscis

The mouth-parts of adult *Tachina larvarum* are prolonged into a proboscis (Figs. 7 and 8) of the sponging type consisting as usual of the rostrum, haustellum and labella.

The rostrum is a more or less funnel shaped structure which is attached from its wide opening to the lower-most part of the head, the proboscis aperture. The rostrum is surrounded by a transparent membrane which is pebbled by minute black spines. Latero-anteriorly the rostrum carries a pair of maxillary palpi which are more or less club shaped. They are dark brown in colour at the base but they gradually become lighter toward their distal ends until they become light yellow at the tips. The bases of the palpi are beset with stout short and long spines. A pair of sclerotised

rods, probably the stipites, lies inside the wall of the rostrum close to the maxillary palpi. These rods are dark brown, and are articulated at their bases with the proximal part of the haustellum. Their free distal ends are flattened. Enclosed within the rostrum is a chitinous brown framework, the fulcrum. The posterior wall of the fulcrum is further extended dorsally into two lightly sclerotised rods at both sides. The lateral and anterior walls form an arched plate with the front wall wanting throughout most of the arch's length. At the distal end of the fulcrum, situated between it and the haustellum, lies a small hyoid structure, the prepharynx, which serves to keep the lumen of the pharynx distended. This structure fits, for the most part of its body, in a depression in the distal end of the fulcrum.

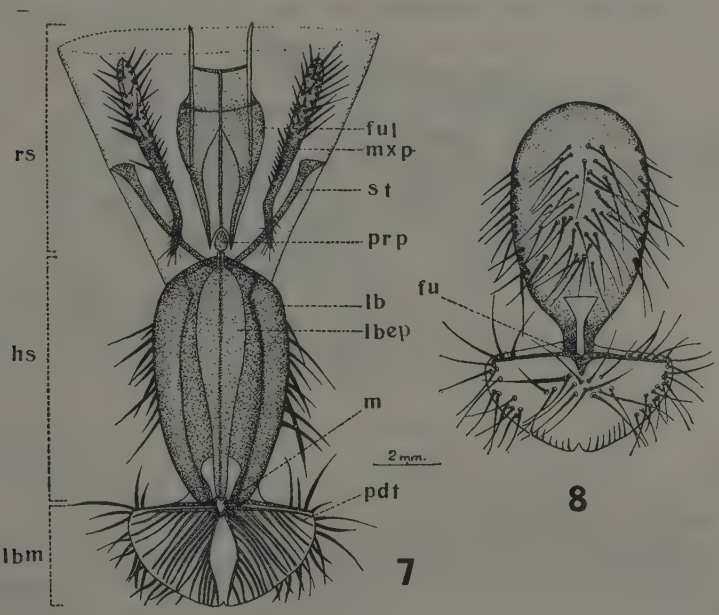

Fig. 7: Proboscis, frontal view (*ful*, fulcrum; *hs*, haustellum; *lb*, labium; *lbep*, labrum-epipharynx; *lbm*, labellum; *m*, mouth; *mxp*, maxillary palp; *pdt*, pseudotrachea; *prp*, prepharynx; *rs*, rostrum; *st*, stipes. — Fig. 8 : Haustellum and labellum, back view (*fu*, furca).

The haustellum comprises, as usual, the labium, the hypopharynx and the labrum-epipharynx. The labium is the biggest structure. It is moderately pigmented, rather boat shaped with its sides stretched anteriorly to form a groove where the other two organs lie. Posteriorly the labium is strengthened by the chitinous theca which is densely covered with long spines on the posterior surface. Distally, the labium is strengthened on both sides with

sclerotised divergent arms which arise at the base of the labella. These arms, the furca, are easily visible from the posterior surface. The labrum-epipharynx is elongate and triangular in shape with a tapering distal end. Its proximal end is connected with the prepharynx. The hypopharynx is also an elongate organ which is attached proximally to the prepharynx.

Towards the distal ends of the labrum-epipharynx and the hypopharynx and at the base of the labella between its two lobes lies a small triangular opening, the mouth or oral opening. Its sides are heavily sclerotised in order to be kept open. The mouth is distitute of any protrusions.

Distally, the labium carries the two labella which are distinctly separated from each other by a longitudinal restriction. The labella are broad soft pads and are almost triangular in shape. Their posterior surface is

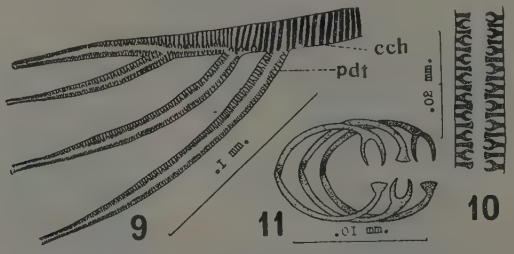

Fig. 9: A part of the pseudotrachea, highly enlarged (*cch*, collecting channel; *pdt*, pseudotrachea). — Fig. 10: Surface view of a part of pseudotrachea. — Fig. 11: Three successive rings of the pseudotracheae to show three alternative ends.

covered with long bristles probably of sensory nature. The anterior surface, however, is distitute of any bristles. This latter surface is traversed by numerous pseudotracheae which are extending from the outer margin, or a trifle from the posterior surface, to the oral orifice.

Each labellum is provided with two common pseudotracheae, the collecting channels, which receive about eight pseudotracheae. Furthermore there are about two to three other pseudotracheae which open proximally in the space between the two collecting channels of each labellum. Each pseudotrachea is kept open by a series of incomplete chitinous rings (Fig. 9). Each ring (Figs. 10 and 11) is bifurcate at one end and single at the other. The single and bifurcate ends of the following rings alternate. The outer openings of the pseudotracheae fall between the two ends of the rings. Each pseudotrachea leads from the outer margin of the labellum to the collecting channel or to the oral orifice. The collecting channels have also similar chitinous rings with normal openings near the margin of the labella. Gradually, however, these openings become narrower till the rings become almost complete near the proximal ends of the collecting channels. Thus it seems

that the distal ends of the collecting channels function as normal pseudotracheae while their proximal ends serve as mere tubes conducting the liquid food to the oral orifice.

Thorax

Owing to the rather complete consolidation of the three thoracic segments, the still undetermined homologies of the various plates and the unsettlement of the concerned terminology, the morphology of the thorax in Cyclorrhapha is still considered incomplete. The following, however, is a brief description of the thorax of *Tachina larvarum* L. (Figs. 12 and 13).

In common with other Diptera, the mesothorax is greatly developed and occupies almost the whole thoracic region while the two other segments, which support only the fore and hind legs, are much reduced.

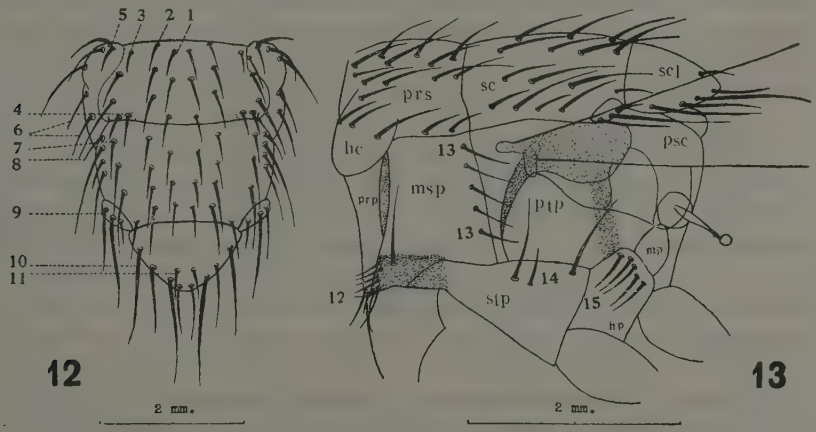

Fig. 12: Thorax, dorsal view. — Fig. 13: Thorax, lateral view (*hc*, humeral callus; *hp*, hypopleuron; *mp*, metapleuron; *msp*, mesopleuron; *prp*, propleuron; *prs*, prescutum; *psc*, postscutellum; *ptp*, pteropleuron; *sc*, scutum; *scl*, scutellum; *stp*, sternopleuron).
Numbers of macrochaeta as in the text.

The general colour of the thorax is metallic yellowish grey with comparatively broad dark stripes exteding longitudinally from the anterior end of the mesothorax to the meso-scutellar suture. The scutellum, however, is dark in colour with metallic yellowish grey patch at its posterior apex. The whole apparent thorax is densely covered with fine, posteriorly directed, hairs.

When the head is removed, the reduced pronotum can be recognised in front and slightly below the level of the mesonotum. The pronotum is almost crescent in shape, shining black in colour and distitute of hairs. The

lateral processes of the pronotum are latero-dorsally associated with the humeral calli. Ventrally these lateral processes are attached to the propleura. These latter are more or less triangular sclerites with their apexes directed ventrally. The ventral parts of the propleura overhang the attachments of the fore-coxae. The prosternum is in the front of a rectangular small sclerite situated between the two fore-coxal foramena. It is provided with few fine bristles on its lateral edges.

The mesothorax, as the wing bearing segment, forms the greater part of the whole apparent thorax. Its notum is divided into the three usual sclerites : prescutum, scutum and scutellum. The prescutum is almost trapezoidal in shape with anterior and posterior margins nearly parallel. Anteriorly the prescutum is bent forward and downward to unite with from the scutellum by the meso-scutellar suture. Laterally bounding the meso-notal suture. Antero-laterally the prescutum is bounded by a pair of strongly convex swellings, the humeral calli. The scutum is the largest sclerite of the mesonotum. It is also trapezoidal in shape. It is separated posteriorly from the scutellum by the meso-scutellar suture. Laterally bounding the meso-notal suture is a pair of small calli, the pre-alar calli, which are situated just antero-dorsal to the roots of the wings. Another more prominent pair of calli is the post-alar calli constituting the postero-lateral angles of the scutum. The scutellum is comparatively small in size and rather triangular in shape. Vertically below the posterior apex of the scutellum lies the post-scutellum. It is composed of a median posteriorly convexed plate which is hidden below the scutellum, and a slightly convexed plate chiefly forming the posterior surface of the thorax and extending ventrally towards the meta-coxal foramena.

The lateral surface of the thorax is rather quadrilateral in shape, the anterior edge being shorter than the posterior. The most anterior sclerite is the propleuron followed posteriorly by a slightly prominent sclerite, the mesopleuron, which occupies most of the anterior area of the pleural region. It is nearly quadrilateral in shape and densely covered with fine hairs.

The mesopleuron is dorsally bounded by the notopleural suture which separates the mesonotum from the pleuron. It is bounded ventrally by the sternopleural suture which separates the pleuron from the sternopleuron. Anteriorly, the mesopleuron is separated from the propleuron by a long furrow, and posteriorly it is separated from the pteropleuron by the meso-pleural suture. The latter suture runs almost to reach the mesonotal suture.

Posterior to the mesopleuron lies the pteropleuron. Its surface is distinctly marked with two prominent areas and is covered with fine hairs. The mesosternum is fused up with the lower portion of the episternum to form the sternopleuron. The latter plate is more or less triangular in shape and

is associated anteriorly with the pro-coxal foramen and postero-ventrally with the meso-coxal foramen. The hypopleuron is polylateral in shape, it is bounded dorsally by the pteropleuron and the metapleuron and anteriorly by the sternopleuron. It is associated by the meso- and meta-coxal foramena. The metapleuron is a comparatively small, rather triangular sclerite bounded by the pteropleuron, the hypopleuron and the lateral plate of the post-scutellum. It is attached to a small circular part, the metathoracic epimeron. which provides a base for the haltere.

Ventrally and posterior to the sternopleuron is a small narrow plate representing the metasternum. This plate is distitute of spines and is very closely connected with the hind coxal foramena.

Other than the macrochaetae which will be discussed later, the dorsal surface and the calli of the thorax are densely covered with fine hairs. The lateral surface, however, is less densely covered with hairs, while the lower part of the sternopleura, the hypopleura and the metapleura are distitute of hair.

Thoracic macrochaetae

Like the cephalic bristles, the thoracic bristles are most valuable in taxonomic purposes. The following are the thoracic macrochaetae of *Tachina larvarum*. The terminology used in this work is after that used by Imms (1946) and Wainwright (1928), both authors had Osten-Sacken (1881) and Girschner (1893) as their guides:

(1) Acrostichals: two rows of bristles extending longitudinally on both sides of the dorsal median line. Each row consists of six bristles, three praesutural, on the prescutum anterior to the mesonotal suture, and three postsutural, on the scutum posterior to the mesonotal suture.

(2) Dorso-centrals: two rows of bristles extending almost parallel to the acrostichals on their outer side. Each row consists of seven bristles, three praesutural and four postsutural. The number of postsutural dorso-centrals is of great value in differentiating the species *rustica* and *erucarum* which have only three of these bristles from the species *fasciata* and *larvarum* which have four of them.

(3) Posthumerals: two rows of bristles situated on the prescutum near the humeral callus. Each row consists of three bristles, the anterior-most of which is the smallest.

(4) Praesuturals: two pairs of bristles, one pair on each side of the prescutum immediately anterior to the suture. The inner bristles are smaller and considered by Wainwright as a praesutural intra-alar while the outer bristles are bigger and considered by Wainwright, following Girschner, as the only praesutural. Wainwright (1928) also sug-

gests to give this latter bristle the term praesutural supra-alar, thus connecting it with the other supra-alars.

(5) Humerals: four bristles, variable in size, visible on each humeral callus.

(6) Notopleurals: two pairs of ristles, one pair on each side of the prealar callus.

(7) Intra-alars: two rows of bristles situated on the scutum, one row on the outer side of each of the post sutural D. C. Each row consists of four bristles varying in size. The most posterior bristle is the smallest and is situated just anterior to the meso-scutellar suture beside the posterior angle of the post-alar callus.

(8) Supra-alars: two rows, each consists of four bristles. Eech is situated on one side of the scutum just dorsal to the base of the wing. The first and third bristles are short while the second and fourth are remarkably long.

(9) Post-alars: six bristles, three being situated on each post-alar callus, the posterior bristle short, the middle comparatively very long and the anterior one rather long.

(10 and 11) Scutellars: these bristles are situated on the scutellum. They are five pairs, four marginal and one discal. The four pairs of marginal scutellars are termed as follows, from the anterior to the posterior part of the scutellum: basal scutellars, lateral scutellars, sub-apical scutellars (longest bristles) and apical scutellars (shortest bristles). The discal scutellars are comparatively short and are situated almost on the same level of the lateral scutellars slightly anterior to the apical scutellars.

All the previous bristles are visible on the dorsal surface of the thorax and are directed posteriorly. The following bristles are seen on the lateral surfaces:

(12) Propleurals: few short bristles situated on the most ventral part of the propleuron very close to the fore-coxae.

(13) Mesopleurals: a row of varied number of bristles situated on the mesopleuron slightly anterior to the mesopleural suture. There are also few other bristles, one of which is exeptionally long and directed dorsally, scattered on the antero-ventral part of the mesopleuron.

(14) Sternopleurals: six bristles, three are situated on each sternopleuron. In his classification of the superfamily Calypterae, Imms gives great importance to the sternopleurals being absent in Oesteridae, usually one posterior and two anterior in Tachinidae and usually two posterior and one anterior in Anthomyidae.

(15) Hypopleurals: one row of bristles situated on the hypopleuron of each side near its posterior edge. These bristles are also of outstanding taxonomic value. Wainwright believes that Tachinidae can be distinguished from all other Muscidae « by the presence on the hypopleura of

a short row of small but distinct bristles placed like a screen just in front of each of the metathoracic stigmata ».

Wings

The wings (Fig. 14) are hinged to the pteropleuron by means of three axillary sclerites. The whole surface of the wing is densely covered with minute hairs. At the posterior margin of the wing, near the base, there is a small membranous lobe, the alula. Proximal to the alula there is another smaller membranous lobe, the anti-squama (outer squama of Snodgrass). Again proximal to the anti-squama there is the squama (calypteron or calypter) which arises from the pteropleuron slightly posterior to the wing base. At the humeral angle there is a small setigerous sclerite, the tegula.

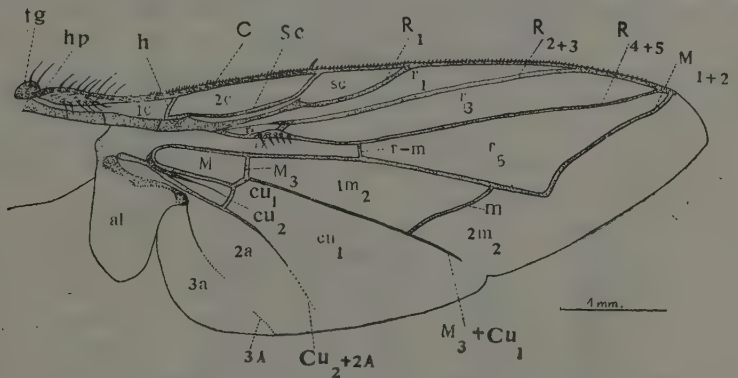

Fig. 14: Wing (*A*, anal; *al*, alula; C, costa; *Cu*, cubitus; *cu*, cubital cell; *h*, humeral cross-vein; *hp*, humeral plate; *M*, medial; *m*, medial cross-vein; *R*, radius; *r-m*, radio-medial cross-vein; *Sc*, subcosta; *sc*, subcostal cell; *tg*, tegula; *1c*, first costal cell; *2a*, second anal cell; *2c*, second costal cell; *3a*, third anal cell).

Associated with the tegula at the base of the costa there is a small elongated plate, the humeral plate. This plate is distitute of setae.

The terminology used in wing venation is after Comstock (1918).

The first anterior vein, the costa, extends from the humeral plate until a short distance before the apex of the wing. It is a remarkably stout vein, its base is thick and is provided with comparatively long bristles. Besides, there are minute setae which cover almost the basal third of this vein. In addition there is a row of small, apically directed bristles which extends along this vein until a very short distance before its end.

The second vein, the subcosta, is a simple vein ending at the anterior margin of the wing and joining the costa before the end of its proximal

half. A small cross-vein, the humeral cross-vein, extends between the costa and the subcosta separating the proximal first costal and the distal second costal cells.

The radius has a broad stem which begins almost at the humeral plate and ends a short distance beyond the humeral cross-vein where it gives rise to three branches. The anterior branch, R_1, runs for its proximal half almost parallel to the subcosta, then it diverges to join the costa shortly after its middle forming the subcostal cell. Very shortly after their beginning, R_2 and R_3 coalesce to form the second branch, R_{2+3} which joins the costa before its end and posteriorly bounds the cell R_1. The third branch, R_{4+5}, represents the coalesced R_4 and R_5. It joins the costa very shortly before its end. Near its base, R_{4+5} has a slightly swollen portion which bears some short bristles on both surfaces of the wing. Posteriorly this branch bounds a proximal small narrow cell, R_2, and a distal large cell R_3.

The media is divided into an anterior long M_{1+2} and a posterior very short M_3+M_4 is, according to Comstock, wanting. M_{1+2} extends to the distal portion of the wing where it bends with a sharp angle to join the costa at its end. A small radio-medial cross-vein (r-m), extends between R_{4+5} and M_{1+2} separating the proximal comparatively narrow radial cell (R) from the distal large R_5 cell.

The cubitus is divided into two short branches. The anterior Cu_1 fuses with M_3 to form the vein M_3+Cu_1 which runs towards an incision in the posterior margin of the wing. This latter vein, however, does not reach the margin. A long cross-vein, the medial cross-vein, extends between M_{1+2} and M_3+Cu_1. Three distinct cells are thus formed : the proximal medial cell (M) closed by the free part of M_3, the intermediate cell, first M_2 cell, closed by the medial cross-vein and the distal second M_2 cell. The second branch of the cubitus, Cu_2, extends posteriorly joining the second analis vein 2A to form Cu_2+2A. This latter extends towards the posterior margin of the wing but does not reach it. Two cells are thus formed : the proximal triangular Cu which is distally closed by Cu_2 and the distal large open Cu_1.

According to Comstock (1918), the first analis, 1A, is wanting. The third analis, 3A, is a weak vein which extends posteriorly, but does not reach the margin of the wing and thus forms two open anal cells. The four posterior cells: $2M_2$, Cu_1, 2A and 3A are thus incompletely separated from each other.

The anal area of the wing is provided with some thickenings and furrows. There is an important thickening in front of the alula which almost separates it from the wing proper. Associated with the base of the third anal vein there is also another important thickening. Besides, there is a furrow which extends along the cell Cu dividing it into two adjacent triangles.

The haltere articulates with the metathoracic epimeron and is covered with the calypter. It is brown in colour and is covered with very minute hair.

Legs

The legs (Fig. 15) are composed of the usual typical segments, yet they differ slightly among each other. The coresponding pair of legs also differ in the two sexes.

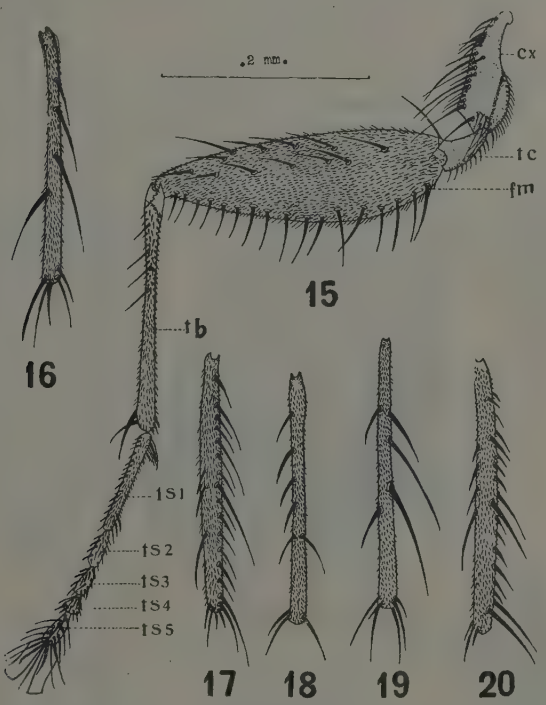

Fig. 15: Fore-leg of male (*cx*, coxa; *fm*, femur; *tb*, tibia; *tc*, trochanter; *ts1-ts5*, first to fifth tarsal subsegment). — Fig. 16: Middle tibia of male. — Fig. 17: Hind tibia of male. — Fig. 18: Fore tibia of female — Fig. 19: Middle tibia of female. — Fig. 20: Hind tibia of female.

The coxa is elongate in shape. Its anterior edge is densely beset with long spines while the distal part of its posterior edge is provided with comparatively short spines. Few short spines are also visible on its distal end. The coxa of the pro-leg is distinctly larger than the other two coxae.

The trochanter is wedge-shaped and is slightly less than half the coxa in size. It is provided with some short spines on its posterior edge and with

few spines on its antero-distal end. The surface of both the coxa and the trochanter is distitute of fine hairs.

The femur of the pro-leg is slightly more swollen than the other two femora. A fringe of long bristles is found on the ventral edge of the femur. On the dorsal edge there are also few bristles which are more densely located on the distal end.

The tibia (Figs. 16, 17, 18. 19 and 20) is little shorter than the femur. In both sexes the hind tibia is distinctly broader than the two other tibiae. Though not a constant character in the individuals of the species, yet the number and position of the tibial bristles represent remarkable variations in the different legs of the same insect and to a limited extent in coresponding legs of the two sexes. In both sexes the anterior tibia is provided with few short bristles which are more frequent on the proximal portion. These bristles are fewer in males than in females. The middle tibia is provided with few long bristles most of which are directed posteriorly. The hind tibia possesses a fringe of long and short bristles along most of its length. The whole surface of both the femur and the tibia is densely covered with fine hairs.

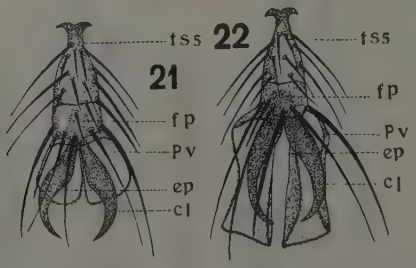

Fig. 21 : Fifth tarsal subsegment and metatarsus of female. — Fig. 22: Fifth tarsal subsegment and metatarsus of male.
cl, claw; *ep*, empodium; *fp*, foot plate; *pv*, pulvilli; *ts5*, fifth tarsal subsegment.

The tarsus is about as long as the tibia. It is divided into five subsegments. The first sub-segment is little less than half the anterior length of the tarsus. A fringe of long bristles is present on its posterior edge, being longer and denser on the proximal part. The remaining four sub-segments are rather conical in shape, their narow ends directed proximally. Their surfaces are provided with short spines. The spines of the last subsegment are, however, longer than those of the other sub-segments. The second sub-segment is longer than the third and the latter is longer than the fourth. The fifth (Figs. 21 and 22) is about as long as the second and carries on the distal part of its ventral surface a trapezoidal plate, the foot plate.

Distally, the last sub-segment bears a pair of claws, a pair of pulvilli and an empodium. The claws are slightly paler in colour than the leg, curved, broad proximally and tapering to a point. They are provided with very minute hairs. The pulvilli present a character of great importance in sex differentiation being small and shorter than the claws in females and large and longer than the claws in males. Sexes can thus be differentiated at a glance by the naked eye. The empodium is a spine-like structure lying between the claws and slightly longer than them.

Abdomen

The abdomen (Figs. 23, 24, 25, 26, 27 and 28) is conical in shape, its apex being directed posteriorly. In general the tergies cover the dorsal lateral and most of the ventral surfaces. The sternites, on the other hand,

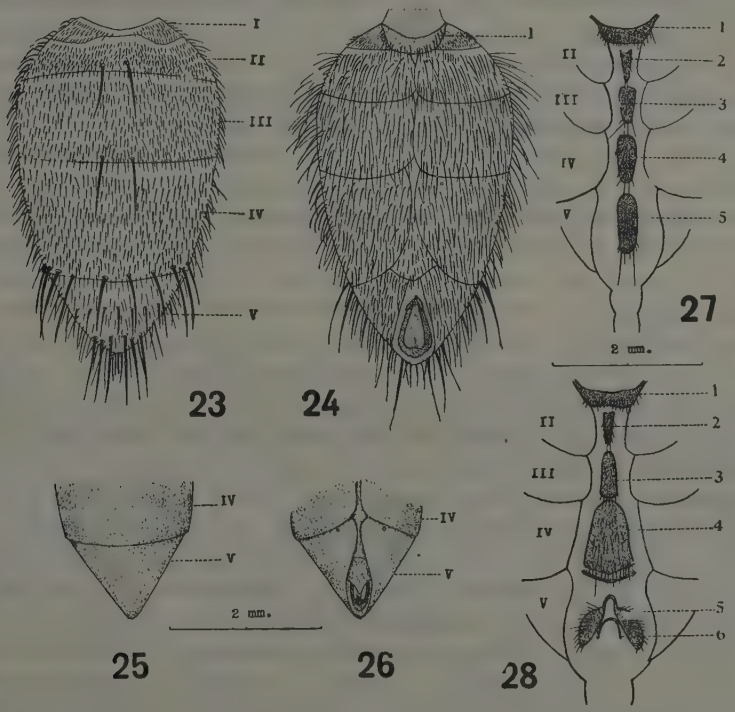

Fig. 23: Abdomen of male, dorsal view. — Fig. 24: Abdomen of male, ventral view. — Fig. 25: Tip of abdomen of female, dorsal view. — Fig. 26: Tip of abdomen of female, ventral view. — Fig. 27: Ventral view of abdomen of female, showing the sternites. — Fig. 28 : Ventral view of abdomen of male, showing the sternites.
(Roman numbers = tergites; Arabic numbers = sternites).

are comparatively narrow sclerites, they are situated mid-ventrally and are almost covered with the ventral edges of the tergites.

There has been considerable difference of opinion concerning the exact number and homologies of the abdominal segments in higher Diptera. Opinions differ mainly as to the exact nature of the first visible abdominal segment. Some authors consider it to represent the fused second and third abdominal segments, the first abdominal being partially fused with the thorax. Other authors consider it to represent the fused first and second abdominal segments. The mere existence of the eigth abdominal segment is also a debateble matter. Patton in his series of studies on the higher Diptera, thoroughly studied the segmentation of the abdomen giving convincing proofs for his conclusions. The following description of the abdominal segmentation and the terminalia is based on Patton's conclusions. Apparently the abdomen consists of four visible segments. If the apparent first abdominal segment is carefully examined, it will be clearly found to be composed of two distinct segments, the real first abdominal and the second abdominal. The real first abdominal segment is a comparatively small segment. Its tergum is very narrow mid-dorsally and slightly increases in width laterally and ventrally. It is covered with fine hairs. The mid-dorsal part and a ventral posterior triangle on each side are, however, bare. The first sternum is a broad almost quadrilateral sclerite with two narrow lateral precesses. It is easily visible from the ventral surface of the abdomen as it is not covered with any tergites. A fringe of hairs is present on the lateral and posterior edges of the sternum. The second abdominal segment is remerkably longer than the first. It has one pair of marginal bristles dorsally. The second sternum is narrow and is almost triangular in shape with its apex directed posteriorly. It is covered with very fine short hair. The third segment constitutes the broadest part of the abdomen. It is about twice the length of the second segment and also carries dorsally a pair of marginal bristles. Sternum 3 is narrow and rectangular or almost triangular in shape being larger in males than in females. It is covered with fine hairs which are longer posteriorly. The fourth segment is the largest segment of the abdomen. It is trapezoidal in shape and tapering posteriorly. Dorsally it carries a row of marginal long bristles. Sternum 4 differs greatly according to sex. In males it is a large almost quadrilateral sclerite, its anterior edge being curved anteriorly and its posterior edge being slightly stretched posteriorly. A faintly sclerotised narrow stripe is associated with the posterior edge of this latter sternum. In females sternum 4 is comparatively small and rectangular or almost triangular in shape. In both sexes the sternum is covered with minute hairs which become denser and longer posteriorly. Looking from the dorsal side, the fifth segment appears to be the most posterior one. It is slightly shorter

than the third segment, conical in shape and tapering apically where its sides are rounded. Ventrally the edges of the fifth tergum enclose an almost triangular or ovoid cavity within which the succeeding segments are telescoped. Dorsally the fifth segment carries a row of discal short bristles in addition to several strong and thick apical bristles. The general form of the fifth segment presents another character of importance in sex differentiation being conical and pointed at the apex in females and laterally convex and rounded at the apex in males. Sternum 5 also differs in the two sexes. In females it is more or less a triangular sclerite and is larger than sternum 4. It is covered with minute hairs and its posterior portion is beset with numerous long bristles. In males, it is composed of a median narrow rounded sclerite to which are attached two comparatively large lateral processes. Each process is provided with a dense fringe of hair. The fifth sternum in males constitutes an important specific character in higher Diptera. Sternum 6 in males is a narrow semi-circular sclerite very closely associated with sternum 5.

Beside the bristles, the whole visible surface of the abdomen is densely covered with thick hairs. The succeeding telescoped segments comprise the male terminalia in the males and the ovipositor in the females.

Five abdominal spiracles are situated on the ventral side of the first five abdominal terga near their anterior edges.

Before dealing with the male and female terminaliae a study of the reproductive systems is deemed desirable.

Male reproductive system

The reproductive organs in the male (Fig. 29) consist of a pair of elongated pyriform testes which are dark brown at the apical portion and gradually become paler toward the posterior end. Each testis gives off a short progressively narrowing duct, the vas defferens. The two vasa deferentia open separately at the dilated proximal end of the unpaired ejaculatory duct. The latter is a long convoluted tube which extends a distance in the body cavity before entering the lumen of the phallosome. Before leaving the body cavity, the ejaculatory duct is dilated to form a small bladder-like structure, the ejaculatory sac, it then becomes thinner and forms a very narrow tube which enters the phallosome. A pair of small accessory glands open separately by very short thin ducts into the dilated proximal end of the ejaculatory duct.

Female reproducitve system

The female reproductive organs (Fig. 30) consist of two ovaries which are in the form of compact oval structures. Each ovary consists of a large

number of polytrophic ovarioles and opens posteriorly into a short comparatively wide oviduct which tapers slightly towards the posterior end. The two oviducts converge towards the mid-line to communicate with a long common oviduct which opens posteriorly into a wide rather pyriform sac, the uterus. The latter is connected posteriorly with a narrow tube, the vagina, which leads to the exterior. There are three dark reddish-brown

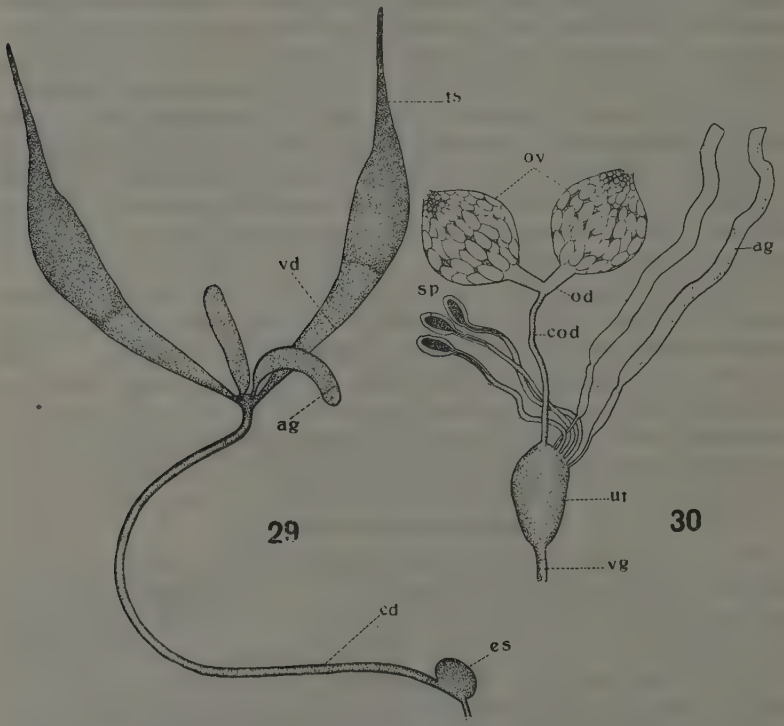

Fig. 29: Male reproductive system (*ag*, accessory gland; *ed*, ejaculatory duct; *es*, ejaculatory sac; *ts*, testis; *vd*, vas deferens). — Fig. 30: Female reproductive system (*ag*, accessory gland; *cod*, common oviduct; *od*, ovident; *ov*, ovaries; *sp*, spermatheca; *ut*; uterus; *vg*, vagina).

spermathecae. Each spermatheca is in the form of an elongated cylindrical chamber with a thick wall which is covered with a cellular layer. The form and colour of the spermathecae vary greatly in the different species of the higher Diptera. Each spermatheca is connected separately with the anterior wall of the uterus by means of a narrow muscular spermathecal duct. The accessory glands are in the form of two long tubes which are of

uniform calibre, except for a small narrow portion at their proximal ends. Each tube opens separately into the uterus on either side of the openings of the spermathecal ducts.

Male terminalia

The term terminalia was adopted by Patton (1932) instead of genitalia as the latter excludes the anal segment, the tenth segment and its appendages. According to Patton (1932) « the terminalia then means the terminal abdominal segments and their embryonic appendages which go to make up the genital and anal appendages ». In higher Diptera the male terminalia has been recently considered of very important significance in taxonomic study. The terminalia in the related families of Sarcophagidae, Muscidae, Calliphoridae and of some Tachinidae was thoroughly studied in a series of publications by Patton. The following description of *Tachina larvarum* male terminalia is based on Patton's findings (Fig. 31).

It has already been mentioned that the sixth to the tenth abdominal segments are telescoped inside the end of the fifth segment. These segments could thus be examined only after being drawn out. The sixth segment is largely membranous. Its tergum is represented by a narrow semi-circular dorsal chitinous sclerite. Sternum six was previously described, it is very closely associated with sternum five. The tergum of the seventh segment is in the form of a curved chitinous yellow brown plate which carries a fringe of comparatively long bristles on the posterior portion of its dorsal surface. Sternum seven is represented by a very narrow thin membrane which is attached to the sternum of the preceding segment. The eighth segment has, according to Patton, entirely disappeared. The ninth segment is the real genital segment as it bears the phallosome and the parameres. It is represented by a narrow incomplete circular plate with no definite tergum or sternum and hence it is termed by Patton the ninth tergo-sternum. Awati (1916), on the other hand, is of the opinion that while the ninth sternum has disappeared this plate represents only the ninth tergum. The ninth segment cannot be seen from the dorsal surface as it is concealed inside the genital atrium. Articulating with the sides of the ninth segment is a pair of comparatively large flap-like valves which were termed differently by the authors dealing with the subject : external valves by Lowne (1895), cerci or styles by Balfour Browne (1932), and paralobes by Wainwright (1932). Patton (1932), however, states that these valves represent the distal segments of the coxites of the ninth segment. In *Tachina larvarum*, each of these structures takes the form of an almost triangular orange-brown plate, its more or less semi-circular base lies at the proximal end. The apex is very dark brown in colour and is provided with long soft bristles. Each valve lies on either side of the tenth tergum just anterior to

the anal cercus and is proximally articulating with it. The tenth segment is represented by the arched tergum only, the tenth sternum has disappeared. The tenth tergum is densely covered with long bristles which are especially dense on the dorsal surface. The tenth segment is also called the anal segment because it carries the anal opening slightly below its posterior edge. Attached to the posterior margin of the tenth tergum are the anal cerci (internal valves of Lowne (1895), mesolobe of Wain-

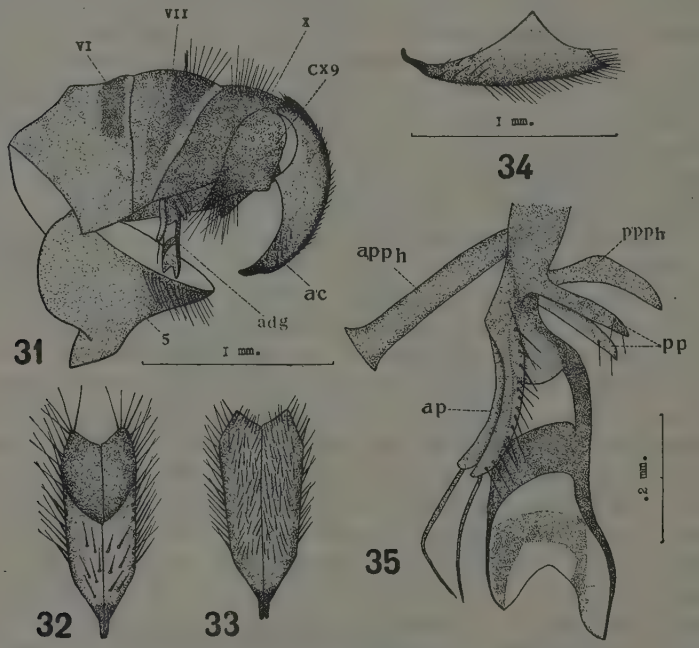

Fig. 31 : Male terminalia, side view (*ac*, anal cerci; *adg*, aedeagus; *cx 9*, distal part of ninth coxite. Roman numbers = tergites; Arabic numbers = sternites). — Fig. 32; Anal cerci, frontal view. — Fig. 33: Anal cerci, back view. — Fig. 34: Adal cerci, side view. — Fig. 35: Phallosome (*ap.* anterior paramere; *apph*, apodeme of phallosome; *pp*, posterior paramere; *ppph*, posterior process of paramere).

wright (1932)) (Figs. 32, 33 and 34). These cerci are directed anteroventrally. According to Patton (1932) they represent the appendages of the obsolete eleventh segment. The two cerci which are absolutely separated in lower Diptera, are intimately united along their inner borders to form one boat-shaped structure. Their very tips, however, are very slightly separated from each other. The anal cerci are brown in colour and their tips are little darker than the rest of the body. Each anal circus is in the form of a long almost triangular plate which tapers towards the distal end. The apical por-

tion of each circus is distitute of any hairs while the convex posterior surface and the lateral margins are provided with short hairs distally and comparatively long hair proximally. Few bristles are found on the two sloping lateral surfaces. All the bristles of the anal cerci are directed backwards.

The genital pouch is thus bounded anteriorly by the body of the insect, ventrally by sternum five, dorsally and laterally by the terga of the terminal segments and the coxites of the ninth segment and posteriorly by the anal cerci.

Phallosome

The phallosome (penis or aedeagus) (Fig. 35) is a complicated structure which is associated with the genital segment, ninth tergo-sternum, and lying in the genital pouch anterior to the ninth coxites. It consists of two main parts. The first part is a proximal strongly sclerotized rod-like apodeme, the shaft or the apodeme of the phallosome. Its free end is distinctly flattened while the other end is jointed to the second part, the body of the phallosome or the end piece. This latter part is rather a tubular structure, partly sclerotized and partly membranous. Its distal portion is membranous and densely studded with minute spines. The body of the phallosome holds the terminal part of the ejaculatory duct. The sclerotized part of the phallosome extends posteriorly to form the posterior process of the phallosome. The latter structure tapers apically, slightly bent ventrally and has a hollow ventral surface. On each side of the bare of the phallosome there is a pair of periphallic appendages termed the anterior and posterior gonapophyses, anterior and posterior claspers, anterior and posterior parts of the parameres or simply anterior and posterior parameres. These appendages are attached to the apodeme about the level of the posterior process. The posterior parameres are a pair of sclerotized posteriorly directed sharply pointed rods. Their bases are closely associated with the base of the posterior process. Each posterior paramere carries a pair of bristles, one bristle on each side, near its apex. The anterior parameres are comparatively long curved appendages. They are directed ventrally with their blunt apex slightly directed anteriorly. Each anterior paramere is provided with a row of stout bristles along its posterior border and with a long ventrally directed bristle on its apex.

Female terminalia

The female terminalia (ovipositor) (Figs. 36, 37 and 38) is formed of the sixth, seventh, ninth and tenth abdominal segments. As previously mentioned in the male, the eighth segment has also in the female, according to Patton (1932), disappeared. At rest, the female terminalia is withdrawn inside the fifth abdominal segment. The general form of the ovi-

positor is tube-like slightly tapering apically. Extensive membranous areas separate its sclerites from each other and from the fifth abdominal segment. Tergum 6 consists of two elongated darkly pigmented plates which are separated by a membranous area and carry a fringe of bristles on their postero-dorsal margins. Sternum six is a comparatively large saddle-like sclerite with a narrow posterior end. It is darkly pigmented, the lateral parts, however, being little lighter. The posterior edge of this segment is provided with a fringe of bristles. Tergum seven also consists of two separate elongated plates which are smaller than those of tergum six. The anterior portion and posterior edge of each plate is very darkly pigmented while the rest of the surface is little lighter. Few bristles are present on the posterior

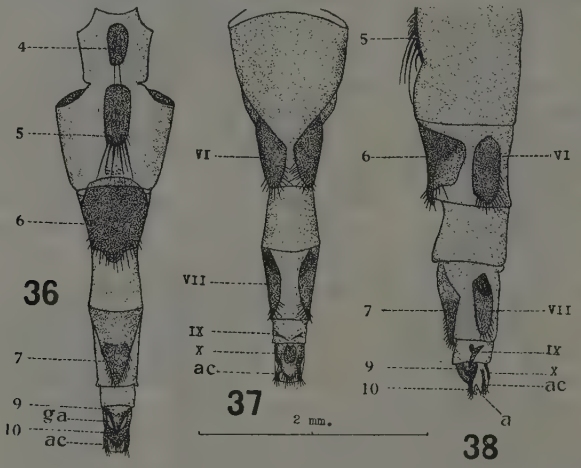

Fig. 36: Female terminalia (ovipositor), ventral view. — Fig. 37: Female terminalia (ovipositor), dorsal view. — Fig. 38: Female terminalia (ovipositor), lateral view.

(*a*, anus; *ac*, anal cerci; *ga*, genital atrium; Roman numbers = tergites; Arabic numbers = sternites).

margin. Sternum seven is triangular in shape. Its distal apex extends slightly beyond the posterior end of the segment. The seventh sternum is pale brown in colour except for a triangular dark brown area at the posterior end. Some bristles are present on the apical part of the edges of the posterior triangle. The ninth segment is comparatively small and narrow. Tergum nine is represented by two minute trifurcate sclerites. Sternum 9 is anteriorly membranous and extends posteriorly beyond the edge of the segment to form a triangular darkly pigmented plate which ventrally covers a portion of the succeeding segment. Both ninth tergum and sternum are devoid of hair. The small tenth segment comprises the apex of the oviposi-

tor. Its tergum is triangular in shape, moderately pigmented with a median darkly pigmented plate on its anterior portion. It is provided posteriorly with few short bristles. Two separate anal cerci, corresponding with those of the male, articulate with the lateral sides of the tergum. Each cercus is posteriorly provided with some few short bristles. Sternum ten is also triangular in shape with its latero-anterior corners extending forwards to bound the genital atrium. The tenth sternum carries few bristles at its posterior end. The genital atrium is thus bounded ventrally by the ninth sternum, dorsally and laterally by sternum ten. The anal opening is situated apically in the tenth segment being bounded dorsally by tergum ten and ventrally by sternum ten.

MORPHOLOGY OF THE EARLY STAGES

Egg

The egg (Figs. 39 and 40) is of the macrotype. It is ovoid in shape with two rounded ends, the anterior end being slightly narrower than the posterior. The ventral surface of the egg is thin and very slightly concave while the dorsal surface is rigid and moderately convex. A weak marginal flange could be recognized, especially at the anterior end, at the juncture

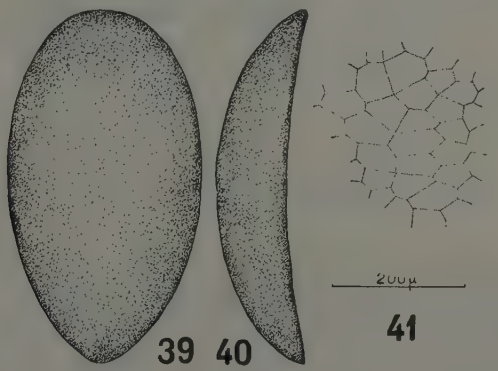

Fig. 39: Egg, dorsal view. — Fig. 40: Egg, lateral view. — Fig. 41: Reticulation of egg, much enlarged.

of the ventral surface with the dorsal arch. Immediately after deposition the egg is creamy white, but as development proceeds it takes a pale yellowish colour. A short time before hatching, one could discern the developing larva within the egg. Its buccopharyngeal armature and integumental spines are plainly visible from the ventral surface. Looking from the dorsal surface, however, the spines could be recognised as faint transverse striations. The surface of the egg is finely reticulated (Fig. 41). Measurements of 33 eggs

were taken, the average length was 0.560 mm. with a maximum of 0.640 mm. and a minimum of 0.510 mm. The average width at the widest part was 0.310 mm. with a maximum of 0.350 mm. and a minimum of 0.260 mm. The width of the egg is thus slightly more than half its length while its height was found to be almost one third its width.

Larval stages

First instar larva

As soon as the egg hatches, the first instar larva (Fig. 42) bores its way into the host integument. The parasite larva increases greatly in size during this instar. Thus while immediately after hatching it averages 0.678 mm. in length and 0.238 mm. in width, it averages 1.238 mm. in length and 0.415 mm. in width at the end of this stage. Its linear dimensions are thus almost doubled during the first stadium. At this stage the larva is almost pyriform, colourless and transparent. It consists of the head and eleven body segments. The head is rather hemi-spherical in shape and devoid of spines, it carries a pair of minute papillate antennae on its latero-dorsal surface. Its bucco-pharyngeal armature (Fig. 43) is a simple unjointed structure which extends posteriorly to the second segment, averaging 0.146 mm. in length and does not change, neither in shape nor in length, throughout the first larval stage. It is composed of a bilobed basal region, an intermediate region and a pointed median tooth. The latter is very minutely serrated at its antero-dorsal edge. Just anterior to the median tooth is a pair of lateral plates and ventral to the intermediate region is a crescent plate, the salivary duct plate. With the exception of the ventral lobe which is very faintly pigmented, the whole armature is deeply pigmented.

All the body segments are provided with dense rows of minute spines. The anterior part of each segment, except the eleventh, is clothed with a band of spines consisting of three to five irregular rows each. The spines on the posterior regions of the segments are arranged as follows: on segments 1, 2 and 3 there is only one row of spines in addition to few scattered spines on the lateral regions. Segments 4, 5 and 6 have only few scattered spines chiefly on the lateral regions. Segment 7 has a complete row of spines in addition to few incomplete rows on its lateral sides. Segments 8, 9 and 10 have complete bands of spines of 2-3 rows each. Segment 11 has no anterior or posterior spines, on the middle of this segment, however, there is a complete band of three irregular rows encircling the posterior spiracles.

Generally the spines on the anterior regions of the segments are directed posteriorly while those on the posterior regions and those of segment 11 are directed anteriorly.

The first instar larva is metapneustic. Just after hatching the two posterior respiratory chambers (Fig. 44) and the posterior spiracles are visible. Later in the instar, however, the other organs of the respiratory system become more easily distinguishable. This system consists of two lateral longitudinal trunks extending along the sides of the body, these trunks taper anteriorly and give off a series of ramifications in the firts body segment. The two trunks are connected with a posterior transverse commissure situated most anteriorly in the eleventh segment, the anterior commissure is, however, missing. Each longitudinal trunk gives off a pair of

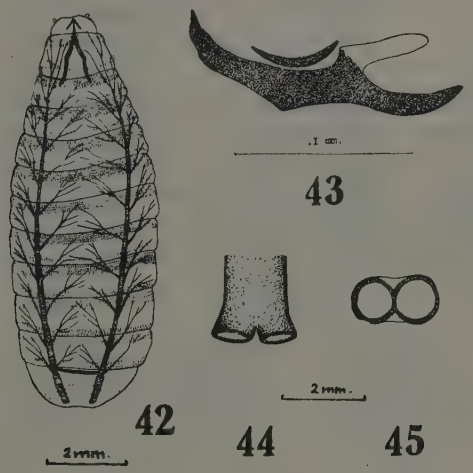

Fig. 42: First instar larva. — Fig. 43: Buccopharyngeal armature of first instar larva. — Fig. 44: Posterior spiracular chamber. — Fig. 45: Posterior spiracle.

ramifying tracheoles in each body segment. The two posterior spiracles open near the apex of the last segment. Each spiracle (Fig. 45) is about 0.021 mm. in width and the distance between the two spiracles is about 0.038 mm. Each spiracle has two very minute adjacent circular openings. The spiracular chambers are more than three times as long as wide.

The first instar larva does not wander in the host body. It remains attached to the host integument, its posterior part remains enclosed in the integumental funnel, and its anterior part moves but very little.

Second instar larva

Like the first instar, the second instar larva (Fig. 46) does not wander in the host body but remains anchored to the respiratory funnel. It also increases in size during the stage averaging about 3.025 mm. in length and 1.512 mm. in width. It is more robust than the first instar larva but its

spines are comparatively short and sparse. Its shape is rather cylindrical tapering anteriorly while its posterior end is truncate. The cuticle is still colourless and more or less transparent. The head is slightly tucked in the first thoracic segment, it tapers anteriorly and is distitute of spines. The bucco-pharyngeal armature (Fig. 47) has no articulations, apparently it is fused into a single piece. This armature is more highly developed than that of the first instar larva, having paired sickle-shaped mandibular hooks instead of the single median tooth. The entire armature averages about 0.349 mm. in length and is almost uniformly dark pigmented. It extends posteriorly to the posterior portion of the second thoracic segment. The ventral lobe of the basal region is divided into two narrow lobes while the dorsal lobe is composed of one single broad plate.

The arrangement, density and position of the spines vary greatly in the different segments. Segments 1, 2 and 3 are provided each with an anterior band of irregular broken rows of spines which are denser on the dorsal than on the ventral surface. No spines are present on the posterior portion of these three segments. The anterior band of segment 4 is less dense than those of the previous segments. Few spines are scattered laterally on the posterior portion of the fourth segment. Segment 5 has one or two irregular broken rows of spines on its anterior as well as on its posterior edges, no spines occur, however, on the dorsal surface of the posterior edge. Segments 6 and 7 have few spines on the lateral and ventral portions of their anterior ends in addition to about four irregular rows of spines on the lateral and ventral portions of their posterior ends. These rows fuse into one row only on their dorsal surfaces. Posteriorly segments 8, 9 and 10 have complete bands of spines which are broader on the ventral than on the dorsal surface. The band of segment 10 is broader than that of segment 9 and the latter is broader than that of segment 8. Anteriorly these segments have few incomplete rows of spines which are similarly broader on the ventral than on the dorsal surface. Segment 11 is covered almost completely with several rows of spines, these rows almost unite with those of the preceding segment.

In general, it may be concluded that the posterior segments are more densely covered with spines than the anterior segments, that the middle segments are the most sparsely covered and that the ventral surface of the larva is more densely covered than the dorsal surface. The spines (Fig. 48) are broad at the base and taper to a pointed end.

The respiratory system is more developed than that of the previous instar. It is of the amphipneustic type. The two longitudinal lateral trunks are connected with two transverse commissures; an anterior transverse commissure (Fig. 49) in the third segment and a posterior transverse com-

missure (Fig. 50) in the last segment. The anterior spiracles (Fig. 51) are very minute and open on the latero-dorsal surface of the second segment. Each spiracle is provided with two minute papillae, each papilla opens with a circular opening. The posterior spiracles (Fig. 52) open near the

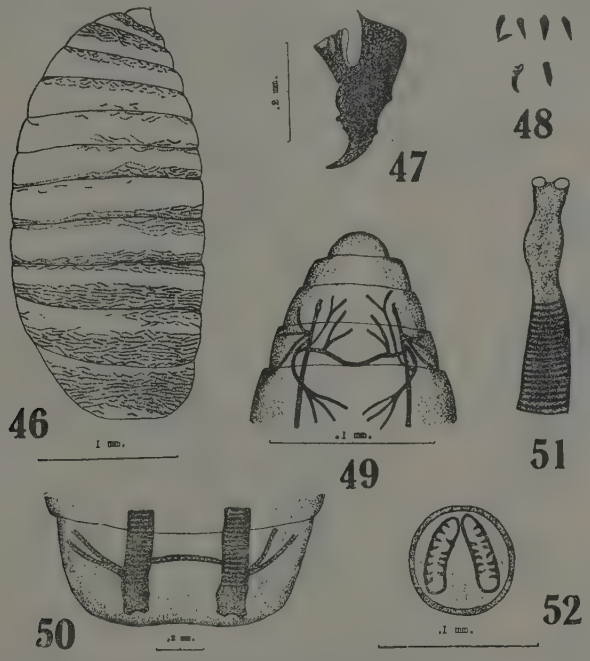

Fig. 46: Second instar larva. — Fig. 47: Buccopharyngeal armature of second instar larva. — Fig. 48: Integumental spines of second instar larva. — Fig. 49: Anterior part of second instar larva, showing anterior part of the respiratory system. — Fig. 50: Posterior part of the second instar larva, showing the posterior part of the respiratory system. — Fig. 51: Anterior part of the longitudinal trachea and anterior spiracle. — Fig. 52: Posterior spiracle of second instar larva.

posterior apex of the larva. Each spiracle has a circular peritreme and two elongated spiracular slits which almost meet dorsally and diverge ventrally. These slits are strengthened by dentated chitinous processes. Each spiracle is about 0.068 mm. in diameter with the distance between the two spiracles averaging about 0.051 mm. The spiracular chamber is comparatively short being slightly longer than wide.

Third instar larva

In the third instar (Fig. 53) the parasite larva leaves its funnel and wanders in its host body. Its dimensions are variable averaging 8.5 mm.

in length and 3.1 mm. in width. It is rather elongated elliptical in shape tapering anteriorly and truncated posteriorly. Its integument is almost colourless and transparent. Normally the head (Fig. 54) is tucked in the prothorax. Anteriorly the head has two distinct cephalic lobes. Each carries a small palp, the maxillary palp, at its apex and a minute antenna lying very slightly behind on the dorsum of the lobe. Ventrally the head carries the more robust bucco-pharyngeal armature. Like those of the previous instars, the head of this instar is devoid of any spines.

The bucco-pharyngeal armature (Fig. 55) is more highly developed than those of the preceding instars. It averages about 0.929 mm. in length and extends to the posterior border of the mesothorax. It has two articulations which separate its three principal regions. The anterior articulation is distinct while the posterior one is not very clearly defined. The mandibular hooks are almost triangular in shape, their tapering anterior ends bend slightly toward the ventral surface. The posterior edge of each hook has three projections : the dorsal, the ventral and the median projections. Ventrally the intermediate region has a protrusion which extends anteriorly and almost meets the median projection of the hook. The ventral lobe of the basal region is equally divided into two plates; the ventral plate is faintly pigmented. The dorsal lobe is more extended posteriorly than the ventral lobe. At its base there is a basal plate which is separated from the rest of the lobe by a distinct suture. The dorso-anterior angle of the dorsal wing of the basal region is strongly produced anteriorly. A pale brown coloured plate is associated with the dorso-posterior angle of the dorsal wing. With the exception of the pale parts which were referred to before, the whole armature is darkly pigmented.

The spines of this instar are relatively minute and are arranged in irregular short rows. On the anterior edge of each of the five anterior segments, there is a complete band of spines which are slightly denser on the ventral than on the dorsal surface. On the ventral surface of segments 6 and 7 the rows of few scattered spines on the anterior portion of each segment almost meet similar rows on the posterior portion of the segment. On the dorsal surface of those segments, however, there are only one or two rows at the anterior end. On segments 8, 9 and 10 there are rows of few scattered spines on both the ventral and dorsal surfaces. They are more sparce on the dorsal surface than on the ventral surface. On the last segment there is no anterior rows of spines, there is only a complete band covering the posterior half of the segment and surrounding the spiracles leaving a bare area around them.

The spines of this instar (Fig. 56) differ in shape from those of the preceding instars being either long or short, single toothed or bidentate. The two teeth of the bidentate spines may be of equal or different lengths.

The third instar larva is also amphipneustic. The respiratory system is relatively highly developed. The two transverse commissures are present. The anterior commissure is easily visible through the larval integument in the posterior portion of the mesothorax. The posterior commissure (Fig. 57) is situated in the last abdominal segment just anterior to the posterior spiracular chamber. Owing to the great density of the adipose tissue, the posterior commissure is not easily distinguished even after dissection. It

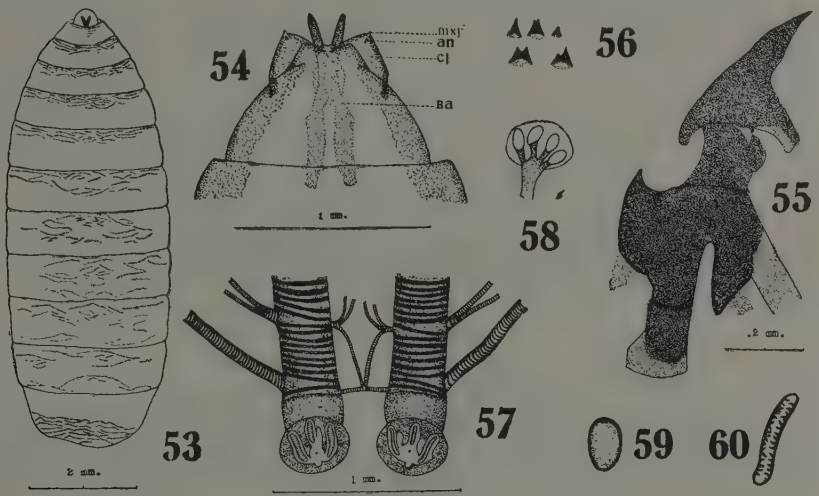

Fig. 53: Third instar larva. — Fig. 54: Head of third instar larva, dorsal view (*an*, antenna; *Ba*, buccopharyngeal armature; *cl*, cephalic lobe; *mxp*, maxillary palp). — Fig. 55: Buccopharyngeal armature. — Fig. 56: Integumental spines. — Fig. 57: Posterior part of the respiratory system, showing posterior commissure and posterior spiracles. — Fig. 58: Anterior spiracular chamber and anterior spiracle. — Fig. 59: One opening of the anterior spiracle. — Fig. 60: A spiracular slit of the posterior spiracle, much enlarged.

is comparatively thin and unites in its middle part with a pair of tracheae which arise from the main longitudinal trunks anterior to the commissure in the last body segment. The anterior spiracles (Fig. 58) open on the latero-dorsal surface at the posterior margin of the prothorax. Each spiracle consists of four finger-like papillae each ending in an oval opening (Fig. 59). The posteior spiracles (Fig. 57) open on the posterior surface of the last body segment. Each spiracle is nearly circular in shape with shining dark brown margin. It has three slightly curved spiracular slits surrounded with pale yellow narrow margins. The three slits are almost radiate from a small dark button, the scar of the preceding instar spiracle, which is located a little ventral to the centre in a yellow circular area associated with the

margins of the spiracular slits. The median slit is remarkably shorter than the others. As in the previous instar, the slits are strengthened by dentated processes (Fig. 60). Each spiracle averages about 0.365 mm. in width and the distance between the two spiracles is about 0.149 mm. The posterior spiracular chambers are comparatively short being shorter than wide.

The anal opening of this instar is situated in the mid-ventral line at the anterior edge of the last segment.

Table II summarises the average dimensions of the three instar larvae of *Tachina larvarum*.

TABLE II

DIMENSIONS IN MILLIMETRES	FIRST INSTAR	SECOND INSTAR	THIRD INSTAR
Length	0.958	3.025	8.500
Greatest width	0.326	1.512	3.100
Length of bucco-pharyngeal armature	0.146	0.349	0.929
Width of posterior spiracles	0.021	0.068	0.365
Distance between the posterior spiracles	0.038	0.199	0.149

Puparium

The puparium (Fig. 61) is more or less barrel-shaped with both the anterior and the posterior ends rounded. It is slightly wider in the mid-abdominal area, about the fourth abdominal segment, where it reaches its greatest width. Immediately after pupation, the colour of the puparium

Fig. 61 : Puparium.

is pale yellow, then it gradually darkens until it finally becomes dark reddish in colour. As the puparium is formed from the skin of the third larval instar, it shows the same segmentation and arrangement of spines of this larval instar. The anterior and posterior spiracles of the third instar larva are also still retained in the puparium. The anterior spiracles appear as a pair of minute papillate structures at the anterior end of the puparium and slightly dorsal. The posterior spiracles, on the other hand, are in the form of button-like structures, slightly raised above the surface of the puparium and are situated at the posterior end. The spiracular slits correspond in form to those of the last instar larva, thus they are of great importance

in identifying the puparium. Between the two posterior spiracles and slightly ventral is a small groove which represents the anal opening.

The dimensions of the puparium are as follows: average length 8.1 mm. with a maximum of 10 mm. and a minimum of 6.1 mm.; average width 3.9 mm. with a maximum of 4.9 and a minimum of 3 mm. The proportion of width to length averaged 47.4% with a maximum of 52% and a minimum of 41%. The dimensions of the puparia, however, vary according to various factors.

An experiment was carried out to determine the effect of sex and food on the size of the puparium.

Both the length and width of 120 puparia (60 males and 60 females) were measured. The puparia of each sex-group represented three sub-groups, of 20 puparia each, as follows :

Sub-group I: One parasite puparium per host pupa.

Sub-group II: Two parasite puparia per host pupa.

Sub-group III: Three parasite puparia per host pupa.

The results are given in Table III, and show that:

TABLE III

The average dimensions of puparia, males and females, in the three sub-groups

DIMENSIONS IN MILLIMETRES	SUB-GROUP I		SUB-GROUP II		SUB-GROUP III	
	20 males	20 females	20 males	20 females	20 males	20 females
Average length.....	9.4	8.9	7.3	7.2	6.8	7.2
Average width	4.5	4.2	3.5	3.4	3.2	3.4
Average length of both sexes	9.2		7.3		7.0	
Average width of both sexes	4.3		3.5		3.3	

(1) Male puparia are generally a little larger than female puparia; (2) the amount of food consumed during the larval stage affects the size of larvae and thence the size of puparia; and (3) deficiency of food seems to affect the two sexes differently. When there was one male puparium per host the average length and width were 9.4 and 4.5 mm. respectively; when there were two puparia per host the average length and width of the male puparia were 7.3 and 3.5 mm. respectively with an average decrease of about 21% in host length and width; when there were three puparia per host the average length and width of the male puparia were 6.8 and 3.2 mm. respectively, with an average decrease of about 29% in both length and width.

On the other hand, when there was one female puparium per host, the average length and width were 8.9 and 4.2 mm. respectively; when there

were two or three puparia per host the average length and width of female puparia were 7.2 and 3.4 mm. respectively with a decrease of about 19 % in both length and width.

This means that males, which are little larger than females, need more food during their larval stage than females in order to attain normal size.

SUMMARY

As a contribution to our knowledge of the parasitic fly *Tachina larvarum* L., a study of the morphology of the adult and the early stages was carried out. The methods used in breeding the host and the parasite are described. The external morphology of the adult is discussed. The head and its appendages are described. The statements in literature to the effect that the frons in males is narrower than in females is shown to be true only when measurements are taken in proportion to the width of the head. Cephalic macrochaetae are described; position of facials is used to differentiate *Tachina larvarum* from *Tachina fasciata*, front-orbitals are shown to exist in females only. Antenna is aristate and more than the apical half of the arista is bare. Proboscis is of the sponging type.

Thorax is described. Mesothorax occupies almost the whole thoracic region. Thoracic macrochaetae are described; the taxonomic value of the number of post-sutural dorso-centrals is indicated, this number being three in *Tachina rustica* and *erucarum* and four in *fasciata* and *larvarum*. Wings have three axillary sclerites. Each wing is composed of the wing proper, alula, anti-squama and squama. Wing venation is described; M_4 and first analis is wanting. In the legs the number and position of tibial bristles vary in different legs and to a certain extent, in different sexes. Pulvilli are bigger in males than in females.

Apparently the abdomen consists of four visible segments. In fact it consists of five segments and of a terminalia consisting of four segments. Segment 8 is wanting. Terga and sterna of abdomen are described.

The male terminalia, its terga, sterna and appendages are described. Articulating with segment nine is a pair of triangular valves, distal segments of ninth coxites, and posteriorly attached to tergum 10 is a pair of anal cerci which are intimately united along their inner borders to form a boat-shaped structure. The phallosome is associated with segment 9. It is composed of an apodeme and a body which has two pairs of parameres and a posterior process.

The female terminalia, the ovipositor, its terga and sterna are described.

Both male and female reproductive systems are described.

The morphology of the early stages is also discussed.

The egg is of the macrotype. It averages about 0.56 mm. in length and about 0.31 mm. in width.

The three larval instars are described. They live internally in the host body. Arrangement of spines, bucco-pharyngeal armatures and respiratory systems are described in detail.

The puparium is described. Its dimensions are affected by sex and by the number of puparia per host.

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Studies on *Tachina larvarum* L. (Diptera, Tachinidae)

III. BIOLOGY AND LIFE-HISTORY

(with 11 Text-Figures and 15 Tables)

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INTRODUCTION

The biology and life-history of *Tachina larvarum* L. was but very poorly studied. Though it was considered one of the most important parasites of *Prodenia litura* in Egypt, yet few observations have been made as concerning its biology, life-history and the real role it plays in controlling the pest. The aim of this paper is to study these aspects and to determine accurately the role of the parasite in controlling *Prodenia litura* in Egypt.

EMERGENCE

When about to emerge, the adult insect thrusts off a cap-like operculum at the anterior end of the puparium by the pressure exerted by its ptilinum. The movements of the legs and of the backwardly directed body spines help

the insect to leave its puparium. The hinge of the operculum lies at the first abdominal segment of the puparium (Fig. 1). Due to the pressure exerted by the emerging fly, the operculum is vertically split into two almost equal parts between which the fly makes its way out. *Tachina larvarum* pupates either in the soil near the host pupa or inside the host pupa itself. In the latter case, the adult after leaving its puparium forces its way out through a hole at the anterior end of the host pupa. If more than one parasite puparium are present within one host pupa, each fly emerges through a separate

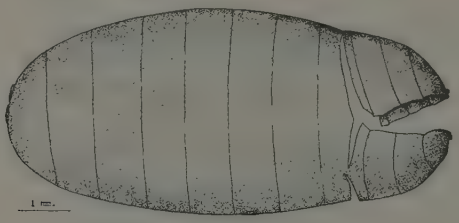

Fig. 1 : Puparium, after emergence.

hole, but one of them always makes its way out at the anterior end of the host pupa. It is only rare that the parasite puparium becomes so orientated in the host body that the emerging fly leaves the host pupa through its caudal end. This was noticed in laboratory breeding in only two cases but was never discovered in the material collected from the field.

It is usual among Tachinids that, under the same conditions, males emerge few days earlier than females. This phenomenon, however, was not quite clear in laboratory breeding of *Tachina larvarum* where the range of emergence seemed almost the same in both sexes.

In cases where there were more than one parasite per host insect, it was noticed that sometimes one of the parasites would pupate within the host while the others would pupate outside it, in the soil, without any effect on their pupal duration.

MATING

Males and females of *Tachina larvarum* readily mate in the breeding cages which were described earlier. The pairing is usually preceded by a momentary struggle between the two flies after which they remain more or less stationary. Usually the female stays on a substratum, extending her ovipositor posteriorly. The male mounts over her back bending his terminalia ventrally and anteriorly to insert his aedeagus into the female genital atrium. All the female legs rest on the substratum, the male hind and middle legs also rest on the substratum while his fore legs surround the female head

almost at the region of the compound eyes. From time to time the female gently passes her hind legs along the posterior part of the male's abdomen. Mating flies may either remain at the same place during the process or occasionally fly while still in coitus from one place to another. In some instances copulation is carried out while the two flies are standing still with their posterior extremities opposite to each other. In other instances the whole process may be accomplished while the two flies are lying on their back, the male lying with his back on the floor of the cage and the female lying with her back on his venter. The male terminalia would bend upwards while he catches the female's head with his fore legs.

The flies usually prefer to mate during the morning hours though they were observed to mate around noon time in the laboratory. The process takes several hours. Table I shows the mating period for nine pairs of flies

TABLE I

Mating period

PAIR NUMBER	TIME OF COMMENCEMENT IN HOURS AND MINUTES	TIME OF SEPARATING IN HOURS AND MINUTES	PERIOD OF PROCESS IN HOURS AND MINUTES
1	9.00	12.30	3.30
2	8.30	12.00	3.30
3	9.15	13.40	3.25
4	8.00	12.40	4.40
5	10.15	14.00	3.45
6	12.05	14.30	2.25
7	8.00	13.05	5.05
8	12.00	14.10	2.10
9	12.15	13.15	1.00

at an average temperature of 27.5° C., and that the maximum mating period is about five hours, while the minimum period is one hour with an average of about 3.15 hours.

Usually the flies begin mating on the second or third day after their emergence. In one instance, however, a female emerging at 10 a.m. was noticed to mate with a male that had emerged two hours earlier around noon time on the day of their emergence. In this instance mating continued for two and half hours. Thus *Tachina larvarum* seems able to mate few hours after emergence. On the other hand the maximum time between emergence and mating was 22 days in confinement at 26.5° C.

In some Tachinidae female flies never mate more than once, in others repeated mating is common (Clausen, 1940). In *Tachina larvarum* both males and females were observed to mate more than once either with the same or with different flies. The maximum number of matings accom-

plished by a couple of *Tachina larvarum* was twelve times within a period of 17 days at the end of which the female died while the male lived six more days. In another instance one male was noted to mate with two females respectively each for about three hours with an interval of about half an our between the two matings. On the average, the number of matings per individual is about three.

Females seem to attract males in the field. In August 1949 a cage containing few females was set in the field at Giza. At 11 a.m. two males were seen hovering around the cage and they finally came to rest on the cage's wire. They were then caught and admitted into the cage and in less than twenty minutes they were seen mating with the females.

PRE-OVIPOSITION PERIOD

Just after emergence adult females do not show fully developed eggs in their ovaries. The pre-oviposition period varies according to temperature being about two to three days in summer and six days in winter. When females were kept at a temperature of 31° C. in the laboratory the pre-oviposition period was reduced to one day only. The amount of food consumed during the larval stage does not seem to affect the pre-oviposition period. There was no difference in this period when one or three females were bred on a single host. The pre-oviposition period of the females of the two groups was the same, about two days at a temperature of 27° C. Virgin females lay eggs parthenogenetically without any effect on the duration of the pre-oviposition period.

OVIPOSITION

Generally the female begins the act of oviposition by approaching the host larva and staying still near it. Sometimes it would lay her fore-legs on it. In most cases the fly approaches the host from one side but occa-

Fig. 2: Larva of *Prodenia litura* with *Tachina* eggs on its integument (inset enlarged).

sionally it may approach it from the back or the front. When about to oviposit, the female slowly extends its ovipositor anteriorly between its legs until its tip becomes as close as possible to the host body when it suddenly sticks an egg to it (Fig. 2). Usually the female rests for a few minutes

before depositing another egg. Not very rarely, however, does it deposit two successive eggs on two different host larvae in less than one minute. Because the females most often approach their hosts from the sides, the eggs are almost always deposited transversely on the host's longitudinal axis.

Tachina larvarum female flies are not keen about depositing all their eggs on the host integument. In confinement, though *Prodenia* larvae were available, few eggs were deposited on cotton and clover sprigs, on the wooden and wire walls of the cage, on the glass walls of the vials, on the bodies of other flies and on many other materials in the cage. It may be worthy to note that all these eggs are complete loss as the maggots that hatch from them cannot gain entrance into a host larva. The writer failed to notice such dislocated eggs in the field.

DISTRIBUTION OF PARASITE EGGS ON HOST BODY

Eggs are deposited on any part of the host body including the head, thoracic legs and abdominal prolegs. But by far the greatest number of

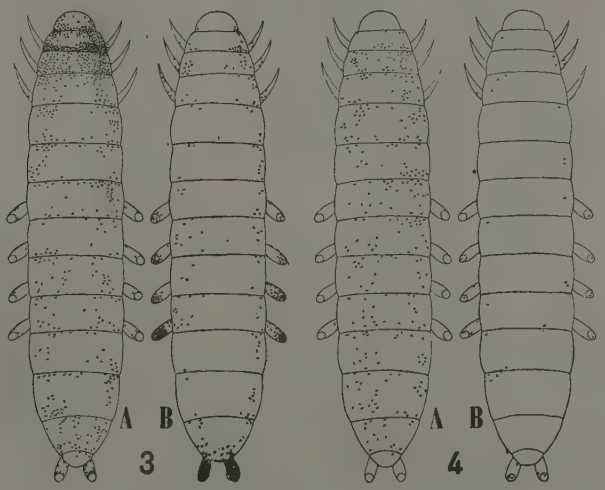

Fig. 3: The position of 1141 *Tachina* eggs on *Prodenia* body in the laboratory, each dot represents the position of one egg. — Fig. 4: The position of 350 eggs on *Prodenia* body, in the field.
(*A*, Dorsal and latero-dorsal; *B*, Ventral and latero-ventral).

eggs are laid on the dorsal and latero-dorsal sides of the host body. The distributon of 1141 eggs that were deposited on *Prodenia* larvae in the laboratory is recorded diagrammatically in Figure 3. Likewise the distribution

of 350 eggs deposited on *Prodenia* larvae collected in the field is also recorded and shown diagrammatically in the same way in Figure 4. Table II shows the number and distribution of eggs deposited in the laboratory and in the field on different segments and legs of *Prodenia* larvae.

TABLE II

Distribution of Tachina *eggs on head, segments and legs of* Prodenia *larvae*

PART OF LARVA	NUMBER OF EGGS DEPOSITED	
	LABORATORY	FIELD
Head	42	0
First thoracic segment	164	16
Second thoracic segment	153	41
Third thoracic segment	70	30
First abdominal segment	60	39
Second abdominal segment	48	28
Third abdominal segment	44	30
Fourth abdominal segment	31	28
Fifth abdominal segment	41	22
Sixth abdominal segment	45	23
Seventh abdominal segment	31	26
Eighth abdominal segment	52	31
Ninth abdominal ssgment	60	15
Tenth abdominal segment	29	1
First thoracic legs	5	0
Second thoracic legs	7	2
Third thoracic legs	11	1
Third abdominal legs	15	1
Fourth abdominal legs	20	2
Fifth abdominal legs	30	4
Sixth abdominal legs	55	5
Tenth abdominal legs	128	5
TOTAL	1141	350

It is concluded from the figures and Table II, that :

(1) In the field and in the laboratory most eggs are deposited on the dorsal and the latero-dorsal sides of the host larva. The proportion of the eggs laid on the ventral side in the field, however, is very small as compared with those laid in the laboratory.

(2) Not very few eggs are laid on the head of the host larva in the laboratory. No eggs, however, are laid on the ventral surface of the head. This side seems tc be rather inaccessible to the parasite.

(3) In laboratory experiments the first and second thoracic segments received the greatest quota of eggs. These segments seem to be most vulnerable, since it is very difficult for the host larva to reach the female parasite at that region. Usually the host larva bends its head and thorax posteriorly to dislodge the attacking parasite.

(4) In the field, it was noticed that the maximum number of eggs was on the second thoracic segment, that, with the exception of the first thoracic,

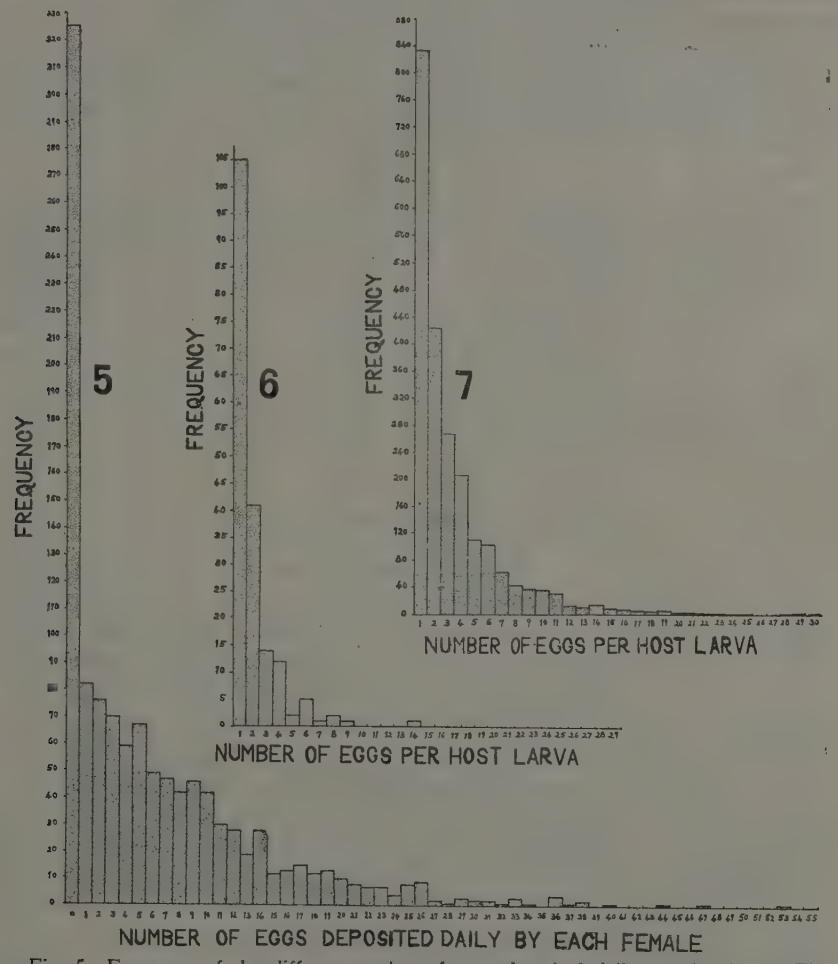

Fig. 5: Frequency of the different number of eggs deposited daily per female. — Fig. 6: Frequency of different number of eggs per host larva in the field. — Fig. 7: Frequency of different number of eggs per host larva in the laboratory.

there was not very much difference between the number of eggs on the other segments, and that the ninth and tenth abdominal segments received the least number of eggs.

(5) Of 350 eggs laid in the field, not a single egg was deposited on the head of the host.

(6) The last abdominal segment, constituting the posterior surface of the host larva, received the smallest number of eggs in field and laboratory experiments, presumably due to its comparatively small area.

(7) A good number of eggs are laid on the abdominal prolegs especially when the host is exposed to the parasite in confinement. The last abdominal prolegs seem to be accessible to the flies attacking the host from the back.

(8) Many eggs are deposited on and around the hooks of the abdominal prolegs.

(9) The thoracic legs, presumably due to their small size and chitinous nature and the ease with which they can be defended, received a comparatively very small number of eggs. This is especially true with field larvae.

When several host larvae are exposed to a female *Tachina*, they are not all necessarily attacked. One or more larvae may be attacked while the others may escape parasitism. In one instance five full grown *Prodenia* larvae were exposed to one female of *Tachina* for twenty four hours. One larva received 57 eggs while the other four escaped parasitism. This phenomenon is probably less evident in the field.

NUMBER OF EGGS LAID PER DAY

The number of eggs deposited daily per female varies greatly. Fifty newly emerged females were isolated singly in breeding cages and provided with one male each. Sufficient number of *Prodenia* larvae were exposed daily to each female and the total number of eggs laid by each female was recorded. It was noticed that the females would generally stop laying from time to time for one or more days during their oviposition period and that few days before their death they stop laying altogether.

It was also noticed that few normally developed females deposited very few eggs. This phenomenon will be dealt with later when discussing the relation between the amount of food consumed during the larval stages and the fecundity of adults.

The result of this experiment is recorded in Table III and is also shown in Graph-Figure 5.

From Table III it can be seen that :

(1) Not all host larvae that come in contact with *Tachina* females are necessarily attacked.

(2) The number of eggs laid daily per female ranges from 0 to 53. Mostly from 1 to 14 eggs are laid each day.

(3) The maximum number of eggs laid per day per female as recorded in this experiment is 53 (in another experiment this number was 57).

(4) These conclusions are based on 1155 observations.

TABLE III

Number of eggs laid daily per female Tachina
(based on the study of 50 females)

NUMBER OF EGGS	FREQUENCY	NUMBER OF EGGS	FREQUENCY	NUMBER OF EGGS	FREQUENCY
0	325	18	12	36	4
1	82	19	13	37	1
2	76	20	10	38	2
3	70	21	8	39	0
4	59	22	7	40	1
5	67	23	7	41	0
6	49	24	4	42	0
7	47	25	8	43	1
8	42	26	9	44	1
9	46	27	2	45	0
10	42	28	1	46	0
11	30	29	3	47	1
12	28	30	2	48	0
13	19	31	2	49	0
14	28	32	1	50	0
15	12	33	3	51	0
16	13	34	1	52	1
17	15	35	0	53	1

TABLE IV

Number of eggs per host larva in field collections

NUMBER OF EGGS PER HOST LARVA	FREQUENCY	NUMBER OF EGGS PER HOST LARVA	FREQUENCY
1	105	8	2
2	41	9	1
3	14	10	0
4	12	11	0
5	2	12	0
6	5	13	0
7	1	14	1

NUMBER OF EGGS PER HOST LARVA

The number of eggs deposited on each host larva also varies. From thousands of *Prodenia* larvae collected from the field at Giza in July and September 1949, 184 sixth instar larvae were found infested with eggs of *Tachina larvarum*. The number of eggs per larva is shown in Table IV and in Graph-Figure 6.

In the laboratory a total of 5825 sixth instar *Prodenia* larvae were exposed to females of *Tachina larvarum* in oviposition cages. Five larvae were exposed to each female every twenty four hours. *Tachina* eggs were

laid on 2231 of these larvae. The number of eggs per larva is recorded in Table V and Graph-Figure 7.

Tables IV and V show that :

(1) In the field as well as in the laboratory most host larvae harbor one or two parasite eggs. The proportion of larvae having more than two eggs gradually decreases with the increase in number of eggs per larva.

TABLE V

Number of eggs per host larva
(based on laboratory experiments)

NUMBER OF EGGS PER HOST LARVA	FREQUENCY	NUMBER OF EGGS PER HOST LARVA	FREQUENCY
1	834	16	7
2	423	17	5
3	268	18	4
4	205	19	6
5	110	20	3
6	102	21	3
7	62	22	2
8	42	23	2
9	37	24	1
10	36	25	1
11	30	26	0
12	13	27	0
13	9	28	1
14	14	29	2
15	18	30	1

(2) In field collections the maximum number of parasite eggs per host larva was 14 while in the laboratory this number was 30.

In another experiment it was shown that the number of parasite eggs per host larva is affected by the size of the host, as it will be shown later.

POST-OVIPOSITITON PERIOD

Normal female flies live for a certain period after they actually stop ovipositing, this is the post-oviposition period. Post-mortem dissection of these females reveals the almost complete absence of eggs in their ovaries. Many females, on the other hand, would continue to lay eggs until they die. The dissection of such females, however, would reveal the presence of fully developed eggs in their ovaries. This indicates that their death was accidental. The post-oviposition period varies from one to seven days and it generally increases with the fall of temperature.

INCUBATION PERIOD

The incubation period varies greatly according to temperature. In the laboratory it differs from three days in summer (June to September, with

an average temperature of 26.5° C.) to nine to ten days in winter (average temperature 24° C.). In the field it is about three days in summer and from 21 to 27 days in winter. At a constant temperature of 27° C., the incubation period varied from 66 to 67 hours. The incubation period has a very important bearing on successful parasitation of host larva as will be shown later.

MODE OF HATCHING

Hatching takes place by lifting up the convex dorsal surface of the egg. The line of fracture extends along the anterior half of the egg separat-

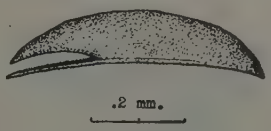

Fig. 8: Egg, after hatching, lateral view.

ing its ventral surface from the dorsal arch (Fig. 8). In most cases as soon as hatching takes place, the parasite larva penetrates the host integument just in front of the egg.

LARVAL ACTIVITIES OF TACHINA LARVARUM

First instar larva

Because the newly hatched first instar larva is presumed to gain entry into the host body as soon as hatching takes place, its thin cuticle is devoid of scales or other integumental modifications which guard against desiccation. In most cases the hatching larva begins boring into the host integument while its caudal end is still enclosed in the egg. The parasite larva does not wander much on the host body before making its entrance hole. In some cases the near edge of the entrance hole is found adjacent to the anterior end of the egg. In most cases, however, a certain distance, averaging about 0.15 mm., is found between the anterior end of the egg and the edge of the entrance hole. In few cases, larvae were observed to crawl for few minutes on the host integument before beginning to bore into it. The entrance hole averages about 0.15 mm. in diameter. Penetration takes place at almost any part of the body including the abdominal prolegs. Larvae hatching from eggs deposited on the head capsule or the thoracic legs of the host larvae fail to penetrate these parts. They either migrate to the nearest part of the host body through which they can bore, or perish through

desiccation before gaining entry. Likewise a large number of the newly hatched larvae die when the moult skin to which they are attached is shed off and they fail to reach a suitable host. On the average the period between hatching and complete penetration of the host integument does not exceed 15 minutes. Most parasite larvae that fail to get into the host body before such period may perish through desiccation. It is recorded that some Lepidopterous host larvae make frantic efforts to destroy or dislodge the Tachinid larvae while attempting to penetrate their integument. This phenomenon, however, was not noticed in the case of *Prodenia* larvae attacked by *Tachina larvarum*. The host larva seems to show no reaction to the process of the parasite penetration.

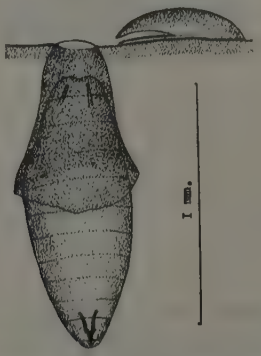

Fig. 9: First instar larva after entering the host body, showing entry hole and respiratory funnel.

The activities of the first instar larva of *Tachina larvarum* inside the host body are very confined. After the maggot bores its way into the host body, a funnel is formed from the integument of the host around the entry hole (Fig. 9). This funnel encloses the posterior part of the parasite larva from the eighth body segment backwards. The parasite larva anchors itself into the funnel with its posterior end directed towards the host integument and its anterior part towards the host body cavity. It thus maintains contact and respires the atmospheric air by keeping its posterior pair of spiracles closely associated with the narrow opening of this funnel on the host integument. The funnel, termed the integumental respiratory funnel, is brown in colour with its wide part a little paler than its narrow end.

The first instar larva does not feed on any vital organs of the host body, but feeds on the body fluids and few adipose tissue cells.

Second instar larva

The activities of this instar larva within the host body do not differ much from those of the first instar larva. The posterior part of the larva is still enclosed in the integumental funnel which increases in length and width to cope with the increase in size of the developing larva. The parasite larva at this stage still feeds on the host's body fluids and adipose tissue cells, no vital organs are attacked and hence no external symptoms of parasitism could be recognised.

Third instar larva

The duration of the third instar is comparatively short, not exceeding one to two days in summer. Early in this stage, the activities of the larva do not differ from those of the preceeding instar. Shortly, sometimes few hours later, the larva becomes more active and feeds vigorously on the internal organs of the host including the vital organs. It abandons the integumental funnel and wanders about in the host body cavity. The host is normally now at the pupal stage and the parasite is ready for pupation. The pupating parasite larva most often becomes so oriented that its anterior end comes to lie towards the posterior end of the host. If there are more than one parasite per host insect, at least one of them should take the previous orientation while the others are usually arranged almost longwise in the host body. As the parasite larva leaves the respiratory funnel, it makes a minute incision at the anterior end of the host pupa by pressing the wall open with its caudal end. Usually some of the host body fluids exude through this incision and dry around its external borders. The incision will thus become more noticeable and parasitism can be more easily detected. This incision permits the passage of air inside the host body and thereby insures the provision of sufficient supply of oxygen to the developing parasite. In cases where more than one parasite larva are present, each larva makes an incision in the part of the host integument close to its posterior end and thus guaranties an adequate supply of atmospheric air. In very few laboratory breedings experiments, it was observed that the host larva failed to pupate after its contents were consumed by the parasite. The parasite larva was still able to press open the host integument for respiration and pupated either inside or outside its body.

After consuming the body contents of its host, the full grown parasite larva is now prepared to pupate. In most cases it leaves the host body to pupate in the soil. As the larva is mostly occupying the host anterior region while its head lies almost at its middle region, so the parasite larva leaves the host body through an amorphous hole in its middle (Fig. 10). If more

than one parasite larva are present, however, each larva leaves it through a special hole. It is not infrequent that one parasite larva of the host abandons it to pupate in the soil while the other larva pupates inside the same host. In most cases the full grown larva was noticed to reverse its position within the host body just before pupation to take the same orientation of the host.

Matthey (1924) working on what he assumed to be *Tachina larvarum* described the mechanism of larval respiration as follows : « *Tachina* eggs are deposited near the spiracles of the host, as soon as the egg hatches the maggot takes its way into the host body through one of the spiracles and engages itself in a longitudinal tracheal trunk so that its posterior spiracles are directed towards one of the host spiracles. It feeds on the

Fig. 10: Parasitized pupa of *Prodenia* after issuance of parasite larva.

internal lining of the trachea. As growth proceeds, the breadth of the larva reaches that of the trunk and the larva breaks the trachea open keeping its posterior portion enclosed in it. The funnel is thus composed of the stub of the trunk, its spiral taenidia being consumed and hence not visible in the funnel ».

It is clear that this mechanism is a radical departure from what is known in Tachinidae and from what was found by the writer in *Tachina larvarum*. This leads to the contention that the material at Matthey's disposal was not *Tachina larvarum*. His drawings of the posterior spiracles of the third instar larva show that they differ from those of *Tachina larvarum* and lend further support to this contention.

PUPATION

In most cases the full grown parasite larva abandons the dried host pupa to pupate in the soil near and almost on the same level of the host pupa. It was previously mentioned that when more than one parasite per host are present, one parasite may pupate in the soil while the others may pupate within the host. Generally the period between the parasite's issuing from the host and its pupation does not exceed three to four hours in summer while it may be prolonged to about twenty-four hours in winter in the field. Most of the few puparia which are formed within the host pupae

take the same orientation as their hosts and adult flies thereby make their emergence at the cephalic end of the host pupa.

LIFE-CYCLE AND DURATION OF THE DIFFERENT STAGES

The duration of the different stages of *Tachina larvarum* varies with temperature. Table VI shows the average duration of the different stages of the parasite in the laboratory in both summer and winter months.

Table VII represents the shortest and longest cycles of *Tachina larvarum* in the laboratory and in the field in both summer and winter.

From Tables VI and VII it can be seen that :

TABLE VI

Life-cycle and duration of different stages of Tachina larvarum *in summer and winter in the laboratory*

STAGE OF PARASITE	DURATION IN DAYS	
	SUMMER TEMPERATURE 28° C.	WINTER TEMPERATURE 24° C.
Incubation period.....	3	5
First larval instar.....	4	6
Second larval instar...	2	4
Third larval instar....	2	3
Pupal stage.....	7	14
TOTAL.....	18	32

TABLE VII

Shortest and longest life-cycle of Tachina larvarum *in the laboratory and field in summer and winter*

STAGE OF DEVELOPMENT	LABORATORY		FIELD	
	SUMMER TEMPERATURE 30° C.	WINTER TEMPERATURE 24° C.	SUMMER TEMPERATURE 27.4° C.	WINTER TEMPERATURE 13.4° C.
Incubation period.....	3	10	4	27
Duration of larval stage	6	10	8	16
Duration of papal stage	7	16	8	35
TOTAL.....	16	36	20	78

(1) The shortest life-cycle of *Tachina larvarum* was 16 days in the laboratory at 30° C. while the longest was 78 days at 13.4° C. in the field.

(2) While the incubation period is very much affected and prolonged by the fall of temperature, the duration of the pupal stage is moderately affected and that of larval stage is comparatively less affected.

It was observed during the laboratory breeding experiments that the life-cycle of *Tachina larvarum* varies with the number of parasites per host individual. When hosts of the same age and size were used it was found that the cycle varied from 32 days when there was one parasite per host to 28 days only when there were two parasites per host. This difference is aparently due to the prolongation of the larval stage when there is one parasite per host on account of the presence of an available supply of food. On the other hand, when more than one parasite larva are present within the host, the larvae readily consume their host contents in a comparatively shorter time and thus pupate earlier. The effect of the amount of food consumed during the larval stage on the fecundity of the adult female will be dealt with later.

The effect of the size of *Prodenia* larvae on the life-cycle of the parasite was not studied since parasitism by *Tachina* is only successful when it attacks the host at a certain stage.

FECUNDITY

Under laboratory conditions it is not easy to determine accurately the number of progeny per female due to difficulties of various sources. Many parasite larvae die in the course of their competition for food which results from super-parasitism. The limited supply of host larvae and the limited space in oviposition cages make super-parasitism inevitable. Many other parasite larvae also fail to complete their development on account of the premature death of their hosts in the breeding cages. Under these circumstances it was deemed necessary to determine the fecundity by estimating the number of eggs laid by each female.

Fifty pairs, one male and one female each, of newly emerged *Tachina larvarum* flies were thus isolated separately in oviposition cages. They were fed on honey and provided daily with five newly moulted sixth instar *Prodenia* larvae each. The number of eggs deposited per day on each host larva was counted. This process was continued from the day of emergence of the female till its death. The results of this experiment are recorded in Tables VIII and IX.

Table IX summarises the informations which were brought about from this experiment.

Furthermore, Tables VIII and IX show that :

(1) The average number of eggs deposited by one female is about 149 with a maximum of 351 and a minimum of 15.

(2) The average number of *Prodenia* larvae parasitised by one female throughout its life is about 42 with a maximum of 85 and a minimum of 5.

Table VIII

Number of eggs laid daily per female Tachina larvarum

| DAYS AFTER EMERGENCE | FEMALE NUMBER | | |

TABLE VIII (continued)

Number of eggs laid daily per female Tachina larvarum

| DAYS AFTER EMERGENCE | FEMALE NUMBER | | |

TABLE IX

Results of fecundity experiments

FEMALE NUMBER	LONGEVITY	NUMBER OF LARVAE PARASITISED	NUMBER OF EGGS LAID	AVERAGE NUMBER OF EGGS PER HOST LARVA	AVERAGE NUMBER OF EGGS LAID PER DAY	AVERAGE NUMBER OF LARVAE PARASITISED PER DAY	AVERAGE TEMPERATURE
1	21	39	119	3.05	6.26	2.05	25.7
2	4	5	18	3.60	4.50	1.25	25.5
3	38	82	270	3.29	7.30	2.22	27.1
4	17	22	94	4.27	5.88	1.38	25.7
5	15	25	65	2.60	5.00	1.92	25.7
6	17	29	74	2.55	4.63	1.81	25.6
7	24	44	116	2.64	5.52	2.10	22.3
8	23	85	351	4.13	15.26	3.70	23.4
9	53	72	190	2.64	3.59	1.36	22.3
10	42	64	185	2.89	4.40	1.52	22.1
11	51	81	207	2.56	4.14	1.62	20.2
12	27	57	190	3.33	7.31	2.19	22.2
13	27	24	34	1.42	1.26	0.89	22.8
14	36	60	206	3.43	6.24	1.82	22.5
15	33	43	167	3.88	6.19	1.59	22.5
16	26	53	193	3.64	7.42	2.04	30.0
17	8	17	88	5.18	11.00	2.12	30.1
18	10	17	81	4.76	8.10	1.70	30.3
19	15	30	118	3.93	7.87	2.00	29.8
20	12	21	143	6.81	11.92	1.75	30.0
21	19	51	147	2.88	7.74	2.68	29.6
22	16	48	205	4.27	12.81	3.00	29.7
23	11	29	171	5.90	15.55	2.64	29.8
24	24	52	245	4.71	10.21	2.17	29.0
25	10	15	31	2.07	3.10	1.50	28.5
26	26	42	153	3.64	5.88	1.62	28.9
27	22	45	193	4.29	8.77	2.05	27.6
28	16	31	84	2.71	5.25	1.94	27.7
29	15	19	48	2.53	3.20	1.27	27.7
30	39	71	232	3.27	5.95	1.82	27.2
31	32	80	317	3.96	9.91	2.50	25.1
32	15	18	72	4.00	4.80	1.20	27.7
33	33	63	245	3.89	7.42	1.91	26.9
34	7	8	16	2.00	2.29	1.14	27.2
35	23	58	227	3.92	9.87	2.52	26.9
36	26	58	174	3.00	6.69	2.23	26.9
37	21	56	166	2.96	7.91	2.67	27.0
38	13	16	39	2.44	3.00	1.23	27.2
39	17	47	262	5.57	15.41	2.76	26.8
40	7	12	29	2.42	4.14	1.71	26.9
41	24	63	326	5.17	13.58	2.63	26.8
42	37	49	200	4.08	5.41	1.32	25.3
43	26	33	112	3.39	4.31	1.27	25.7
44	29	52	173	3.33	5.97	1.79	25.7
45	27	34	158	4.65	5.85	1.26	25.7
46	25	43	148	3.44	5.92	1.72	25.7
47	38	13	22	1.69	0.58	0.34	25.3
48	14	5	15	3.00	1.07	0.36	25.5
49	26	64	194	3.03	7.46	2.46	25.1
50	28	54	121	2.24	4.32	1.93	24.9
AVERAGE	23.3	41.98	148.68	3.54	6.38	1.80	

(3) The average number of *Prodenia* larvae parasitised per day per female is 1.8 with a maximum average of 3.7 and a minimum average of 0.34.

RELATION BETWEEN NUMBER OF PARASITES PER HOST AND THE FECUNDITY OF DEVELOPING FEMALES

Three groups of eight females each were allowed to deposit their full quota of eggs in the laboratory in the same manner as in the preceding experiment. Group I consisted of females each had been bred singly on one host, group II consisted of females each had been bred with another fly on one host, and group III consisted of females each had been bred with other two flies on one host. The number of eggs deposited by each female and its longevity are recorded in Table X which shows that :

TABLE X

Fecundity and longevity of three different groups of Tachina larvarum *females*

FEMALE NUMBER	GROUP I		GROUP II		GROUP III	
	NUMBER OF EGGS	LONGEVITY	NUMBER OF EGGS	LONGEVITY	NUMBER OF EGGS	LONGEVITY
1	326	24	88	8	84	16
2	351	23	81	10	72	15
3	185	42	193	22	166	21
4	190	27	227	23	29	7
5	206	36	174	26	200	37
6	232	39	173	29	112	26
7	262	17	158	27	148	25
8	194	26	121	28	22	38
AVERAGE	243	29	152	21.5	104	23

(1) There is a significant inverse correlation between the average number of eggs deposited by the female and the number of flies per host in the preceding generation. This correlation is obviously due to the fact that the number of eggs deposited by the adult female is mainly determined by the amount of food it consumes during its larval stage.

(2) It seems that when more than one *Tachina* larva are present in one host, some of the larvae may consume sufficient amount of food and thus deposit normal number of eggs, while some others are not able to obtain their full requirements and thus deposit smaller number of eggs.

(3) Though there is a remarkable increase in the average longevity of adults bred singly on host insects, yet it seems that longevity is affected to a large extent by environmental factors during the adult stage more than the amount of food taken in the larval stage.

(4) The number of deposited eggs is not correlated with longevity of the adult fly.

PARTHENOGENESIS

Unmated females deposit eggs as readily as mated females. Copulation influences neither the pre-oviposition period, the number of eggs laid nor the number of host larvae parasitised. The maximum number of eggs deposited by an unmated female in the laboratory was 185. All such eggs fail to hatch.

Parthenogenetic egg-laying, however, is not normal in Tachinidae. Clausen (1940) concludes that « it appears to be the general habit to retain the eggs in the ovarioles until mating has taken place, if this does not occur, the eggs in various stages of formation then break down and are absorbed ».

LONGEVITY OF ADULTS

The longevity of adults depends upon several factors, the most important of which are food, temperature and sex. Several experiments were carried out to determine the longevity of the adult *Tachina larvarum* under different conditions. The result of these experiments are summarised in Table XI which shows that:

(1) In nature the average longevity of adults is about 16 days in summer and about 22 days for males and 42 days for females in winter.

TABLE XI

Longevity in days of adults of Tachina larvarum *under different conditions*

CONDITION OF ADULT	TEMPERATURE IN °C.	MALES			FEMALES		
		MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
Adults kept in the laboratory without food	14	2	5	4	3	5	4
Adults kept in the field in summer with water and honey	23.8	5	28	16	7	32	16
Adults kept in the field in winter, with water and honey	11.6	9	38	22	24	51	42
Adults kept in the laboratory in summer, with water and honey	29.5	10	28	17	7	26	18
Adults kept in the laboratory in winter, with water and honey	24.5	12	29	19	14	53	28
Adults kept in ice-box, with water and honey	11	17	97	38	33	88	67
Adults kept in the field, without food	24.9	2	4	3	2	5	3

(2) Generally females live longer than males, the difference between the longevity of the two sexes increases with decrease of temperature. Under laboratory conditions, for instance, this difference was one day in summer (temperature 29.5° C.) and nine days in winter (temperature 24.5° C.). Under field conditions also while there was no significant difference between the average longevity of both sexes in summer (temperature 23.8° C.), there was a difference of 20 days in winter (temperature 11.6° C.). In the ice-box (temperature 11° C.) the difference was 29 days.

(3) There is a regressive correlation between the longevity of adults and the average temperature at which they are kept. This correlation is more significant in females than in males. In the field the average longevity of females was 16 days in summer and 42 days in winter while in the laboratory it was 18 days in summer and 28 days in winter. The average longevity reached its maximum when the flies were stored in the ice-box (temperature 11° C.), males lived an average of 38 days and females an average of 67 days, the maximum longevity of either sex was about three months.

(4) Both sexes survived starvation for an average of three to four days only.

The number of parasites emerging from a single host seems to have no bearing on the longevity of adults. In October and November 1949, females that had been bred one per host lived in the laboratory (temperature 27° C.) 27 days on the average with a maximum of 39 days and a minimum of 14 days, while those that had been bred three per host lived an average of 26 days with a maximum of 38 days and a minimum of 21 days.

SEX RATIO

By counting the number of females and males in 448 individuals, the sex ratio was found 1 : 1. A population of *Prodenia litura* larvae collected on cabbage at Dokki in October 1949 gave emergence to 43 female and 48 male parasites. Thus the sex ratio of 1 : 1 seems to exist in each population of sufficient number. Flies of the same or of different sexes may be bred from the same host. Several authors have pointed out that among the Tachinidae a wide fluctuation in the relative numbers of the two sexes occurs at various times during the season. This phenomenon, however, was not observed in *Tachina larvarum*.

STAGE OF HOST ATTACKED BY THE PARASITE

It was previously mentioned that *Tachina* females may oviposit on any available body in the absence of a suitable host. Thus females may occasion-

ally deposit their eggs on early stages of *Prodenia* or even on pupae when suitable hosts are not available. When *Prodenia* larvae of different stages of development are exposed simultaneously to *Tachina* females, there is a decided preference of the females to deposit their eggs on the advanced stage larvae. An experiment was carried out in the laboratory in which thirty *Prodenia* larvae, five larvae from each larval instar, were exposed at the same time to ten *Tachina larvarum* females for twenty-four hours. The eggs deposited on each larva were counted and the results are shown in Table XII, which shows that there is a decided preference on the part of the ovipositing females to larvae of the last three larval instars. In the presence of larvae of these instars no larvae of the first three instars are attacked. The average number of eggs per host larva was 3.6 in the case

TABLE XII

Number of eggs deposited on different instar larvae of Prodenia *by* Tachina larvarum

PRODENIA LARVAL INSTAR	NUMBER OF EGGS DEPOSITED ON LARVA					TOTAL NUMBER OF EGGS	AVERAGE NUMBER OF EGGS PER LARVA	AVERAGE LENGTH OF LARVA IN MILLIMETRES	AVERAGE WIDTH OF LARVA IN MILLIMETRES
	1	2	3	4	5				
First..	0	0	0	0	0	0	0	2.2	0.4
Second	0	0	0	0	0	0	0	5.0	0.8
Third .	0	0	0	0	0	0	0	11.0	1.2
Fourth	2	1	6	5	4	18	3.6	14.0	2.4
Fifth..	9	1	0	14	7	31	6.2	20.0	3.0
Sixth..	26	21	15	6	16	84	11.8	38.0	6.0

of fourth instar larvae, 6.2 in the case of fifth instar larvae and 16.8 in the case of sixth instar larvae. When the number of eggs per unit area of the exposed surface was compared, however, there was almost no difference among larvae of the last three instars.

SUCCESSFUL PARASITISM AND ROLE OF HOST MOULTING

As the eggs of *Tachina larvarum* are deposited externally on the host integument, they are lost if they are removed before hatching with the larval exuvium during the moulting process. Successful parasitism has thus a very direct bearing on the relation between the incubation period of the parasite egg and the duration of the different larval instars of the host. If the incubation period is as long or longer than the larval stage of the host, there will be virtually complete loss of the eggs deposited on the host and parasit-

ism will be unsuccessful. The host larva will moult and the parasite egg will be removed away before it hatches. Clausen (1940) states that a collection of 235 gypsy-moth caterpillars, each bearing 1 to 33 eggs of *Tachina larvarum*, produced only 4 parasites and that another collection of 252 did not yield a single one. He attributes a part of this loss to the moulting factor.

In fact the parasite eggs which are removed with the moult skin do hatch afar from the host body and theoritically these hatching larvae may cause parasitism if they happen to get in contact with suitable host larvae. Practically, however, this is improbable since the newly hatched parasite larva dies from desiccation if it does not gain entrance into a host body within few minutes after hatching. Hence all the eggs removed with the moulting skin may be safely considered as complete loss.

TABLE XIII

Duration of the different larval stages of Prodenia litura *at a temperature of 27° C.*

PRODENIA LARVAL INSTAR	DURATION IN DAYS
First	2.5 to 3
Second	2
Third	2
Fourth	2
Fifth	2
Sixth	5 to 5.5

An experiment was carried out in a constant temperature incubator (temperature 27° C.) to determine the duration of the different larval instars of *Prodenia litura* at this temperature. The results are shown in Table XIII.

The incubation period of *Tachina larvarum* under the same conditions was found to vary from 66 to 67 hours.

The same experiment was repeated in the field with egg-masses hatching in February 1949. The duration of the different instars of *Prodenia* under these conditions are shown in Table XIV.

Under similar conditions the incubation period of *Tachina larvarum* eggs varied from 16 to 21 days.

It should be noticed that the few *Prodenia* larvae which had longer duration periods at any of the stages than those mentioned in Tables XIII and XIV always died from diseases few days later.

The preceding data of both experiments indicate that under similar conditions, with the exception of the duration of the first instar in the

laboratory experiment, the incubation period of *Tachina larvarum* eggs is longer than the duration of any of the first five instars of *Prodenia*. This indicates that successful parasitism can take place only when eggs are deposited on the last instar larvae of *Prodenia*.

The first instar larvae in the incubator at 27° C. is excluded as naturally it cannot complete a parasite life-cycle besides the improbability of its attack by the depositing female. A great proportion of eggs deposited in the field on larvae of *Prodenia* are thus lost because they are removed away before they hatch with the moult skin of their host larvae.

TABLE XIV

Duration of the different larval stages of Prodenia litura *in the field* (February 1949)

PRODENIA LARVAL INSTAR	DURATION IN DAYS
First	10 to 12
Second	5 to 7
Third	4 to 6
Fourth	6 to 8
Fifth	6 to 8
Sixth	27 to 30

EFFECT OF PARASITISM ON THE HOST

Effect on the host larva

When the host is still in the larval stage, the parasite larva generally feeds on its body fluids and does no harm to any of its vital organs. The parasitised host thus remains active and shows no external symptoms of parasitism. Close examination of its integument under the microscope, however, may reveal the presence of the entrance hole of the first instar parasite larva.

Effect on the host pupa

The parasite larva feeds on the body fluids of the newly formed host pupa, thus no external symptoms of parasitism could be detected on the host at this stage. Few days later the parasite larva feeds more vigorously and attacks the internal organs including the vital organs. The host pupa thus becomes sluggish at first and then ceases to move even if it is pressed with a forceps. The slit which is pressed open at its anterior end at this stage to aid in respiration of the third instar parasite larva becomes visible especially after the exsudation of the host body fluid which leak through

it and dry around its external borders. In due time all the body contents are consumed and the host pupa acquires a special elongated form (Fig. 10) which may be explained as follows:

In the Noctuid pupae the fourth, fifth and sixth abdominal segments are the only free (movable) segments, while all the other segments are fixed (unmovable). The movable segments are telescoped in their place by means of the longitudinal muscles which function as retractors of the abdomen. When the internal contents of the pupa, including these muscles, are consumed, the movable segments are drawn out, the inter-segmental membrane is stretched and dried up and the host takes this special elongated form.

SUPER-PARASITISM

Super-parasitism is that form of parasitism in which a given host is attacked more than once by one parasite species, the broods developing simultaneously. In *Tachina larvarum* super-parasitism is very common. In the laboratory as many as 30 eggs were deposited on a single host larva of *Prodenia*, in the field, the maximum number recorded per host was 14. Usually the high super-parasitised larvae die few days after the parasite eggs hatch. The maximum number of flies that emerge from a single host is four. Bishara (1943), however, states that as many as 8 flies could complete their development inside a single host.

MULTIPLE-PARASITISM

Tachina females attack their host and deposit eggs irrespective of whether these hosts are parasitised by other parasite species or not. *Prodenia* larvae collected in the field and parasitised with *Actia palpalis* or *Barylypa rufa* were noticed to harbour eggs of *Tachina larvarum* on their integument. When *Prodenia* larvae are attacked by more than one species of parasites, it was noticed that generally the elder parasite survives. As parasitism of *Prodenia* larvae by *Tachina larvarum* succeeds only when the last larval instar is attacked, while the other internal parasites of *Prodenia* successfully parasitise the earlier instar larvae, *Tachina larvarum* always fails in competing with these parasites within the host. When both *Tachina larvarum* and *Barylypa rufa* parasitise a sixth instar *Prodenia* larva at about the same time, *Tachina* was noticed to supervene. It never happened that more than one parasite species were noticed to emerge from one *Prodenia* larva.

HYPER-PARASITISM

A small proportion of *Tachina* puparia collected in the field was noticed to be hyper-parasitised by a secondary parasite of the family Chalcididae.

This hyper-parasite was identified by A. B. Gahan, of the United States National Museum as *Dirhinus giffardi* Silv. (Fig. 11). The first record of this Chalcid as a parasite of a Tachinid is in Egypt.

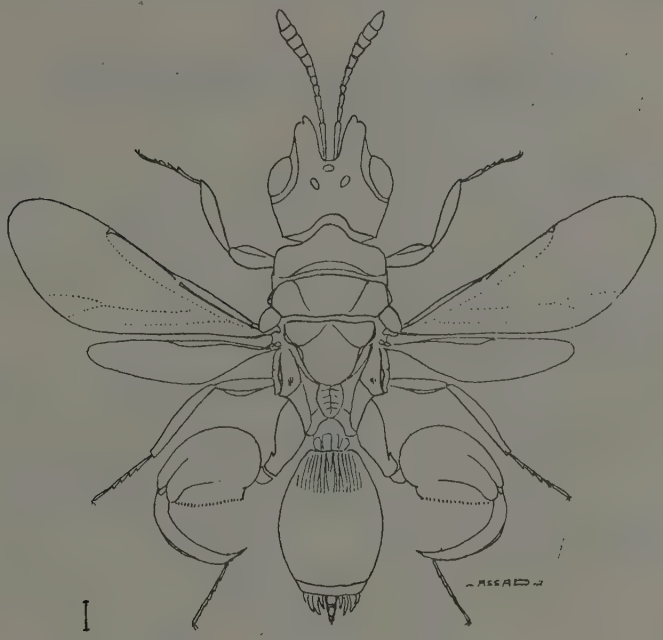

Fig. 11: *Dirhinus giffardi* Silv. (Chalcididae), a hyper-parasite of *Tachina larvarum.*

Hyper-parasitism was noticed only in puparia in the soil, it was not noticed in puparia within the host pupae.

SEASONAL HISTORY

Baer (1920) states that *Tachina larvarum* has two generations per year in Europe, in April and October. This is not the case in Egypt. The number of generations in the field in Egypt is much confused due to their overlapping on account of the great prolongation, especially in winter, of the oviposition period. In winter a generation may take about three months while in summer it does not exceed twenty days. Generally there are almost two generations of *Tachina* for each generation of *Prodenia*. As there are about seven generations of *Prodenia* per year, there are about fifteen generations of *Tachina*. The writer was not able to breed *Tachina larvarum* in the field all the year round and so the exact number of field generations per year is not known.

Comparatively few flies emerge from the winter generation in March and April; as the season proceeds the population of the flies becomes increasingly larger until by late summer and Autumn (September and October) it reaches its maximum abundance.

ROLE OF TACHINA LARVARUM IN CONTROLLING PRODENIA LITURA IN EGYPT

Bishara (1934) concludes from the few data he collected that the average percentage of parasitism of *Prodenia* by *Tachina larvarum* is 1 % in May and June, 5 % from June to August, 30 to 50 % in September and October, 12 % in October on clover and 0 % in November and December.

Willcocks (1937) claims that *Tachina larvarum* may be a very important agent of control and that he has found from 30 to 75 % of the large *Prodenia* larvae in some fields bearing its eggs.

Kamal (1951) thinks that parasitism by *Tachina larvarum* may reach up to 50 or 60 % among *Prodenia* fall brood in September and October.

The writer collected great numbers of last instar larvae of *Prodenia litura* from different localities of Egypt at different months of the year in order to estimate the percentage of parasitism by *Tachina larvarum*. Only the last instar larva was taken into account as it is the only instar suitable for successful parasitism.

Table XV shows the percentage of parasitism in these collections.

TABLE XV

Parasitism of Prodenia litura *by* Tachina larvarum *at different months*

MONTH	NUMBER OF COLLECTED LARVAE	NUMBER OF PARASITIZED LARVAE	PERCENTAGE OF PARASITISM
June.....	290	4	1.4
July.....	929	19	2.0
August.....	2317	93	4.0
September.....	1260	89	7.1
October.....	1527	95	6.2
November.....	235	6	2.6
December.....	204	1	0.5

It is inclued from the collections and from Table XV that :

(1) It is not easy to collect any reasonable numbers of *Prodenia* larvae at the field from January to May.

(2) The percentage of parasitism is low at the beginning of the season, it gradually increases until it reaches its maximum in September and October

when it gradually decreases again until it reaches its maximum in December.

(3) Generally the percentage of parasitism by *Tachina larvarum* is low being supervened by parasitism by the other Tachinid *Actia palpalis*.

It was noticed in some samples collected in October at Giza that the percentage of parasitism by *Tachina larvarum* was as high as 34%.

FACTORS AFFECTING THE EFFICIENCY OF TACHINA LARVARUM IN THE CONTROL OF PRODENIA LITURA

Collections of *Prodenia* larvae made in the field show that the percentage of parasitism by *Tachina larvarum* does not exceed an average of about 7 % and it is usually far less than that. This low degree of parasitism may be attributed to the following :

(1) The failure of the parasite females to deposit their eggs on the right host at the right stage. Many eggs are deposited on inert matter and many others are deposited on earlier host instar larvae and are thus subject to be removed away at the process of moulting.

(2) The first instar parasite larvae are very minute and delicate leading to the mortality of a good proportion of them through dessication before entering the host.

(3) Super-parasitism and the failure of many parasites to complete their development owing to the competition with the other larvae.

(4) The parasite was found nearly always inferior to other internal parasites of *Prodenia* larvae and thus fails in its competition with them.

(5) The percentage of parasitism in the different months of the season indicates that its population is very low at the beginning of the season and that the parasite slowly builds up until it reaches its maximum at the end of the host season when damage by *Prodenia* larvae is already done.

(6) The hyper-parasite, *Dirhinus giffardi* Silv., has a slight effect in decreasing the population of *Tachina larvarum* and thus plays certain role in affecting its efficiency.

SUMMARY

The biology and life-history of *Tachina larvarum* L. together with its role in controlling *Prodenia litura* are studied.

Usually the flies begin to mate one or two days after emergence. Mating period averages 3 1/4 hours. Both sexes mate more than once. Females begin to oviposit 1 to 6 days after emergence. Eggs are laid externally on any part of host body ; dorsal and latero-dorsal parts of thoracic segments are preferred. Number of eggs deposited daily per female ranges from 0 to 53 in confinment. Number of eggs per host larva ranges from 1 to 14 in the field.

As the first instar larva anchors itself to an integumental funnel, formed around the entry hole, where it stays until the third instar larva is reached, the larva respires the atmospheric air through this funnel. Activities of first, second and early third instars are limited. Late in the third instar, the parasite larva quits the funnel, wanders in the host body (which has now reached the pupal stage), open a hole in its integument to permit the passage of atmospheric air and consumes its contents.

Generally pupation takes place in the soil, and in few cases within the host.

The duration of the various stages is as follows : incubation period, 3 to 27 days; larval period, 6 to 16 days; and pupal period, 7 to 35 days. The average number of eggs deposited per female is 149 and the number of *Prodenia* larvae parasitised per female is 42. There is an inverse correlation between the average number of eggs deposited per female and the number of parasite individuals per host in the preceding generation. Unmated females deposit the normal number of eggs but these eggs do not hatch. Longevity of adults varies from 2 to 97 days according to different conditions. Sex ratio is about 1 : 1. Females prefer to oviposit on advanced *Prodenia* larvae, but parasitism is successful only when sixth instar larvae are attacked. When earlier instars are attacked, the parasite eggs are removed away before they hatch in the process of host moulting.

Generally no external symptoms of parasitism is recognised on the host larvae and the newly formed pupae. The parasitised advanced pupae, however become sluggish at first and then all their internal contents are consumed. They acquire a special elongated form.

Super-parasitism is very common. Maximum number of flies that emerge from a single host is 4. Multiple parasitism is also common. When more than one parasite species are present in one *Prodenia* larva, generally other internal parasites outcast *Tachina larvarum*.

Puparia of *Tachina larvarum* are occasionally attacked by *Dirhinus giffardi* Silv. (Chalcididae).

There are about 15 generations of *Tachina larvarum* per year.

Average percentage of parasitism by *Tachina larvarum* in collections of *Prodenia* larvae made by the writer did not exceed about 7 %. Thus, under the present circumstances, the role played by *Tachina larvarum* against *Prodenia litura* is not very great. Various factors affecting this efficiency are discussed.

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Studies on the effect of pollinating insects, especially the honey-bee, on the seed yield of clover in Egypt

(with 4 Text-Figures and 4 Tables)

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INTRODUCTION

Clover (*Trifolium alexandrinum* L.) is the most important cultivated forage crop in Egypt. It is essential to the welfare of Egyptian agriculture, for soil conservation and a balanced agriculture economy. Recognising the clover seed shortage as one of the major farm problems in Egypt, the need for clover seed production has never been more pressing than it is to-day.

Growing clover is needed in soil conserving, crop rotations, and food for livestock. It is one of the most economical method of restoring nitrogen to the soil and as a means of maintaining soil fertility.

The important factors for successful seed production can be outlined as soil fertility, irrigation, control of harmful insects and pollination.

The present studies were made to throw light upon the importance of pollinating insects to clover seed crop.

Clover, like many papilionaceous crops, i.e. alfalfa, red clover, alsike clover, is genetically self sterile and cross pollination is necessary to effect fertilization. Pollen from a plant with different sterility must be transferred to the stigma of the flowers in the same or another plants. The anthers and stigma being enclosed within the keel of the flower, some agency is necessary to transfer pollen from flower to flower.

Although much work has been done on the problem concerning pollination in the world, no published work has been done in Egypt on the effect

of insects, especially the honey-bee (*Apis mellifica* L.) on the seed yields of different crops and fruits.

EXPERIMENTAL METHOD

Experiment I

Studies carried out in two localities involved detailed observations in fields of clover. One acre of clover was chosen at Mounofia in the farm of the Faculty of Agriculture Ibrahim Pasha University, 65 miles north of Cairo. Another acre of clover was chosen at random at Mallaha farm of the Faculty of Agriculture Farouk University, Alexandria.

TABLE I

The number of clover seeds set per head in the farm of the Faculty of Agriculture at Shebin El-Kom

CAGES	MEAN OF SEEDS PER HEAD				MEAN OF THE MEANS
	CAGE I	CAGE II	CAGE III	CAGE IV	
"A" Cloth cage excluding insects and wind currents	0.165	0.215	1.16	0.15	0.44
"B" Screen cage excluding insects	1.140	2.200	1.70	2.75	1.94
"C" Screen cage with honey-bee	41.080	37.400	40.10	37.20	38.90
"D" Control cage in open field	19.900	26.500	25.20	22.60	23.50

Sixteen test cages three cubic feet in size were used in each experiment, to demonstrate to what extent clover is self pollinated, wind pollinated, or insect pollinated.

The test cages were divided into four categories four cages each. Cages « A » were covered with cheese cloth which excludes wind currents as well as pollinating insects. Cages « B » were covered by window screening to exclude pollinating insects but allowing wind to pass through. Cages « C » were covered by window screening and were supplied by a three frame honey-bee nucleus. Wooden frames of the cages with the same size were put in the open field as control, « D ».

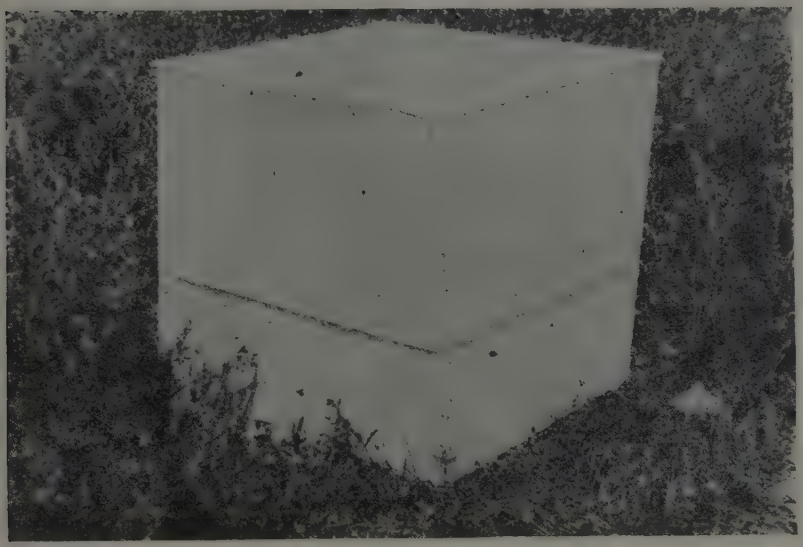

Fig. 1 : A test cage « A » over blossoms of clover which excludes all pollinating insects and wind currents.

Fig. 2: A screened cage « B » excluding pollinating insects.

Fig. 3 : A screened cage « C » over blossoms of clover with a three frame nucleus of honey-bees.

Fig. 4: A row of four different cages: A. Cloth cage; B. Screened cage excluding insects; C. Screened cage with honey-bees; and D. Cages on open plots.

The cages were distributed on clover plants before blooming. When clover was ready for harvesting, the clover in each cage was harvested separately, the heads were kept in separate boxes for each cage for the estimation of the seeds in each head.

TABLE II

The number of clover seeds set per head at Alexandria (Mallaha farm of Alexandria University)

CAGES	MEAN OF SEEDS PER HEAD				MEAN OF THE MEANS
	CAGE I	CAGE II	CAGE III	CAGE IV	
"A" Cloth cage excluding insects and wind currents	0.05	0.16	0.09	0.07	0.09
"B" Screen cage excluding insects	1.20	1.06	1.04	2.04	1.33
"C" Screen cage with honey-bee	45.04	47.06	38.03	40.90	42.75
"D" Control cage in open field	16.50	24.30	20.60	28.70	22.50

RESULTS

The results of the observations on the clover seed set per head in Mounofia are shown in Table I, the seed set per head in Mallaha farm, Alexandria, are shown in Table II, the average seed yield of the two experiments is shown in Table III.

It is clearly shown from Tables I, II and III the effect of the honey-bee in increasing the seed yield of clover.

The mean of the seed set per head of clover in the cloth cages of the two localities was 0.256 per head. This shows that *Trifolium alexandrinum* L. is self sterile and is in need of cross pollination.

The mean of the seed set per head of clover in screen cages which exclude insects was 1.63, definitely shows that clover is not wind pollinated.

The importance of the honey-bee to clover seed yield is shown by comparing the seed yield per head in the cages having honey-bees with that of the control cages. The mean of the seed set per head in the cages having honey-bees was 39.9 at Mounofia, and 42.5 at Alexandria, the average

of the two localities was 40.7. The mean of the seed set per head in the control cages at Mounofia was 23.5, and at Alexandria 22.5, and the average of the two means was 23 seeds per head.

TABLE III

The means of seed set per head of clover in the cages of the two experiments at Alexandria and Shebin El-Kom

CAGES	ALEXANDRIA	SHEBIN EL-KOM	MEAN OF THE MEANS
"A" Cloth cage excluding insects and wind currents	0.09	0.422	0.256
"B" Screen cage excluding insects	1.33	1.940	1.630
"C" Screen cage with honey-bee	42.50	38.900	40.700
"D" Control cage in open field	22.50	23.500	23.000

Experiment II

Observations were made to study the other natural pollinating insects and the ratio of honey-bees to all other visitors to the blossoms of clover.

TABLE IV

Insects visitors observed on flowers of clover from 10th to 22nd May 1951 at Shebin El-Kom, from 9-11 a.m. and 4-6 p.m.

NAMES	NUMBER COLLECTED	%
Honey-bee (*Apis mellifica* L.)	317	59.80
Wild bees (various species)	15	2.82
Carpenter bee (*Xylocopa aestuans* L.)	6	1.12
Yellow wasp (*Polistes gallica* L.)	2	0.42
Cabbage butterfly (*Pieris rapae* L.)	143	27.00
Large tailed blue butterfly (*Cosmolyce baeticus* L.)	30	5.60
Clouded yellow butterfly (*Colias croceus* Fourc.)	9	1.70
Painted lady (*Vanessa cardui* L.)	2	0.42
Syrphid fly (*Syrphus corollae* F.)	6	1.12

Investigations were made in clover field in full bloom. Insect visitors to the blossoms of clover were collected twice daily from the 10th till 22nd of May 1951, from 9-11 a.m. and 4-6 p.m.

The results are shown in Table IV.

The data shows the honey-bee as the outstanding visitor being about 59.8% of the total visitors, the cabbage butterfly was 27%, the large tailed blue butterfly was 5.6%, wild bees were 2.82%, and other insects 4.78%.

The results of this experiment show the importance of the honey-bee to pollination and clover seed production in Egypt.

DISCUSSION AND CONCLUSIONS

The results of McGee and Kelly (1932) showed that the honey-bee to be a very effective pollinating agent for June and alsike clovers and for alfalfa, and the presence of large numbers of bees resulted in marked increases in the seed crop of these plants.

Dunham (1939) concluded that honey-bees devote practically all of their time to gathering pollen from red clover bloom and practically no nectar is gathered. Pollen counts made on unpollinated corollas and on corollas pollinated by honey-bees gave an average of 1153 pollen grains for the first, and an average of only 148 grains for the second, indicating the thoroughness of the honey-bees in pollen collecting. Pollen may get all over the insect body, thus increasing the effectiveness of bees in cross pollination while visiting other red clover blossoms.

Crum (1941) made a test on red clover in Ohio and found 1.1 seeds set per head in cloth cage excluding bees, 55.5 in screen cage with insects, and 63 in open field with bees.

My results provide further demonstration and knowledge of the value of the honey-bee for pollination of clover and the clover seed crop in Egypt.

When comparing the seed yield of clover with honey-bees with that of the open plots, it will be seen that the variation is significant.

Pollination of clover is effected mainly by insects and cross pollination is the rule. It was shown from my observation that over 59.8% of pollination is done by the honey-bee.

The actual counts made in clover fields at Shebin El-Kom gives ample evidence that the honey-bee plays a very important role in pollination of clover in Egypt.

SUMMARY

Studies were made to investigate the importance of pollinating insects, especially the honey-bee, to clover seed crop in Egypt. Two experiments were conducted under this research:

(1) To show the value of the honey-bee to clover seed production.

It was shown that the mean of clover seed set per head under cloth cages was 0.256, the mean of clover seed set per head in screen cages which exclude insects was 1.63, the mean of clover seed set per head in cages with honey-bees was 40.7, and the mean of clover seed set per head in control cages, open plots, was 23.

It will be noticed that the variation is significant and that an ample supply of honey-bees is valuable to clover seed growers.

(2) Actual counts in clover field in full bloom for 12 days at Shebin El-Kom show that honey-bees are found on clover blossoms more than any other insect, constituting 59.6% of all visitors.

ACKNOWLEDGMENTS

I wish to express my indebtedness to Prof. A. El-Nayal, Dean of the Faculty of Agriculture, Ibrahim University, for his helpful suggestions and advice.

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My gratitude is due to Prof. Y. Thabet, Dean of the Faculty of Agriculture, and to Dr. A. E. Hassan, Head of the Entomology Department, Alexandria University, for giving the opportunity to carry out the experiment at the Farm of the Faculty of Agriculture at Alexandria.

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Studies on the normal and pathological histology of the alimentary canal of the honey-bee, *Apis mellifica* L.

[Hymenoptera : Apidae]

(with 10 Text-Figures)

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INTRODUCTION

The adult worker honey-bee normally defaecates outside the hive whilst on the wing, but in the case of a bee that is severely infected with *Nosema apis* excretion within the hive frequently occurs. The abdomen of an infected bee is frequently greatly distended, the rectum being full of fluid containing masses of *Nosema* spores, and contact with another bee on the comb is sufficient to cause defaecation. Such defaecation within the hive results in the contamination with viable spores not only of the comb surface but also of the pollen and honey reserves of the colony and thus leads to the spread of infection within the colony.

Undoubtedly the contamination of honey with viable spores and pollen spores within the hive, and of sources of drinking water outside the hive, are the main sources of infection. The chief ways in which bees become infected with *Nosema apis* are :

I. Within the hive : (a) Feeding on stores of honey and pollen that are contaminated with viable spores ; (b) Modelling wax that has been soiled with excrement of infected individuals ; and (c) Cleaning out excrement voided within the hive by infected bees.

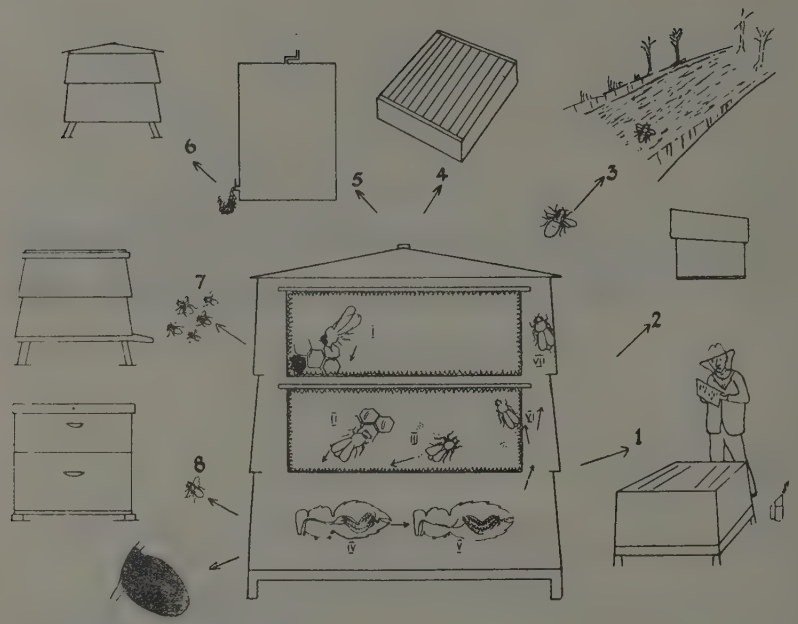

Fig. 1: Diagram of transmission of *Nosema* disease within the hive, and from one hive to another.

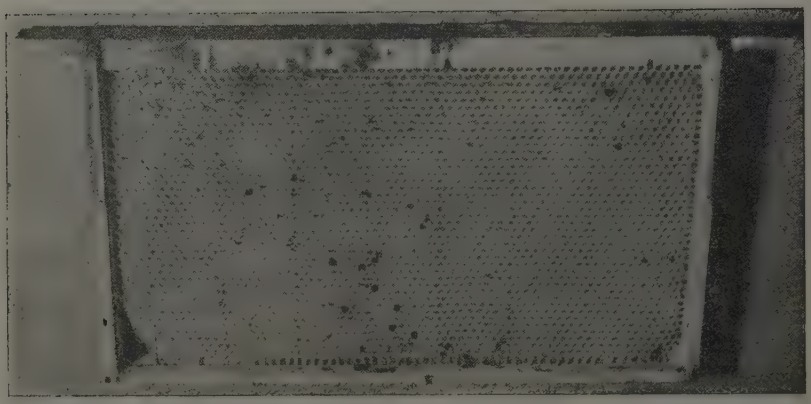

Fig. 2: Frame from colony with *Nosema* disease showing contamination with faeces containing spores of the parasite.

II. Outside the hive: Collecting drinking water from a source, such as perhaps a rain water gutter, that has been soiled by the faeces of bees suffering from *Nosema* disease.

MATERIAL AND METHODS

In order to study the histology of the alimentary canal of healthy bees and that of the infected bees with *Nosema apis*, a number of bees were collected either from the alighting board of the hive or from the feeding hole in the crown board of healthy colonies. These worker bees were divided to two series.

Number of bees were fed individually on fairly concentrated sugar syrup in which viable spores of *Nosema apis* were suspended. Having been infected in this way the bees were transferred to sterilised cages and fed on clean sugar syrup only.

At intervals samples of both healthy and infected bees were taken and histological preparations were made of their alimentary canals. The fixatives usually employed were Bouin-picro-formal and Carnoy, the former was found to be the most satisfactory. After dehydration the alimentary canals were embedded and longitudinal and transverse sections were cut and mounted.

In addition to the permanent preparations, dissections were also made of the alimentary canals of healthy bees and bees that had recently fed on syrup coloured with magenta and containing viable spores. At different intervals after feeding each bee was killed with chloroform, its alimenary canal removed with a pair of forceps (by pulling on the last abdominal segments whilst holding the thorax firmly with forceps) and stretched out on a clean, dry microscope slide which has immediately immersed in absolute alcohol subsequently it was transferred to xylol and dissected in this medium.

HISTOLOGY

In order to describe the results obtained in these investigations, it is convenient to discuss each portion of the alimentary canal separately; and also such organs as the Malpighian tubules, rectal glands which might perhaps be attacked by *Nosema apis*. The various portions of the gut and its associated organs are shown in Figure 3.

Ingestion of contaminated material

According to Snodgrass (1925), when a bee is about to ingest a fluid such as sugar syrup she plunges her proboscis into it, submerging the tips of the maxillary blades and spreading the short terminal joints of the labial palpi outwards. The long, flexible tip of the glossa is bent back and

applied to the food and immediately begins to perform a rapid series of movements backwards and forwards. The fluid commences to pass up through the tube formed by the mouth-parts into the pharynx, carrying with it any spores of *Nosema apis* which may be present.

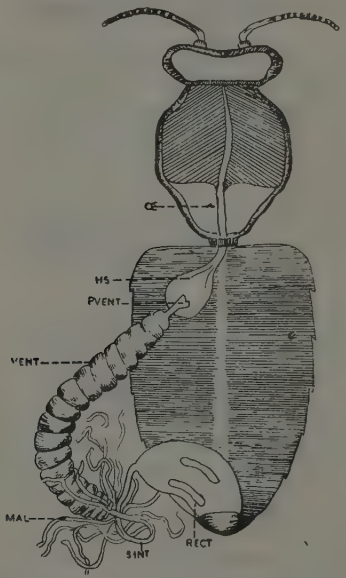

Fig. 3: The alimentary canal of the honey-bee (*HS*, honey stomach; *MAL*, Malpighian tubules; *Œ*, oesophagus; *RECT*, rectum; *PVENT*, proventriculus; *SINT*, small intestine; *VENT*, ventriculus).

The pharynx

The pharynx consists of a triangular-shaped sac situated within the head-capsule, and is the organ which is employed to suck and pump food up via the mouth-parts into the alimentary canal. The epithelium of the pharynx consists of a single layer of cubical cells containing spherical nuclei. In no case did examination of the wall of the pharynx of an infected bee reveal the presence of any of the life-history stages of *Nosema apis*.

The oesophagus

The œsophagus of the worker honey-bee consists of a simple tube which connects the pharynx, via the honey-stomach or crop and proventriculus with the ventriculus. Its epithelium is rudimentary and in transverse sections it is seen to be thrown into a large number of folds. The cells consist of a thin nucleated layer.

No epithelial cells of the œsophagus were ever found to be infected with *Nosema apis*.

The honey-stomach and proventriculus

The honey-stomach or crop is merely a sac-like expansion of the œsophagus and here again the epithelium is thrown into a large number of folds.

The proventriculus takes the form of a thin, hollow stalk which connects the honey-stomach with the mid-gut. It acts as a funnel in introducing food from the honey-stomach into the tube formed by the peritrophic membrane of the mid-gut. No trace of *Nosema apis* was found in the crop, proventriculus or proventriculus valve of any infected bee.

The ventriculus

The ventriculus or mid-gut of the honey-bee is, so far as digestion of food is concerned, the most important part of the alimentary canal. The structure of the ventriculus has frequently been described. It forms the

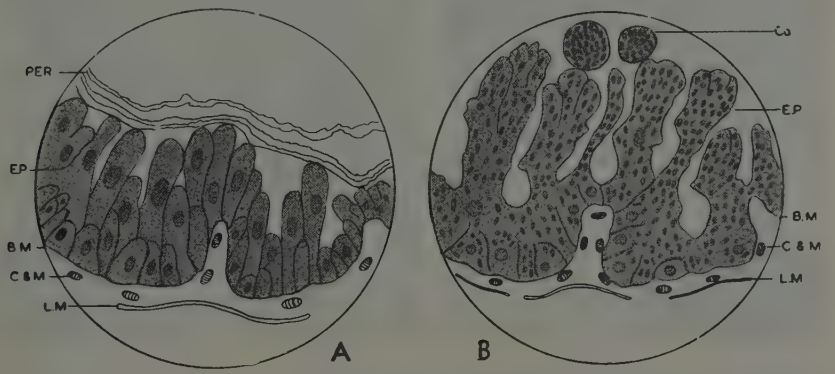

Fig. 4: A. Longitudinal section of ventriculus of healthy honey-bee; B. Longitudinal section of ventriculus of honey-bee showing infection with *Nosema* apis (*B.M*, basement membrane; *L.M*, longitudinal muscles; *C* and *M*, circular muscles; *Ca*, caps; *EP*, Epithelial cells; *PER*, peritrophic membrane).

largest section of the alimentary canal and is bent into a V-shaped loop. In longitudinal section the epithelium is seen to be thrown into regular series of folds (Fig. 4) while in transverse section it is seen to consist of a ring-like band of a tissue falling between two extreme diameters.

It will be seen in Figures 4 and 7 that the wall of the ventriculus contains two series of muscle fibres, an outer longitudinal layer and an inner circular layer. This finding is an agreement with that of Snodgrass

(1925) but is not in agreement with that of White (1918) who described the presence of a third longitudinal muscle next to the basement membrane. At the base of the epithelial cells a very delicate membrane, the basement membrane, is found, which is continuous anteriorly in the œsophageal valve, and posteriorly in the Malpighian tubules and small intestine. The epithelial layer is composed of a large number of cells of various sizes, some of which

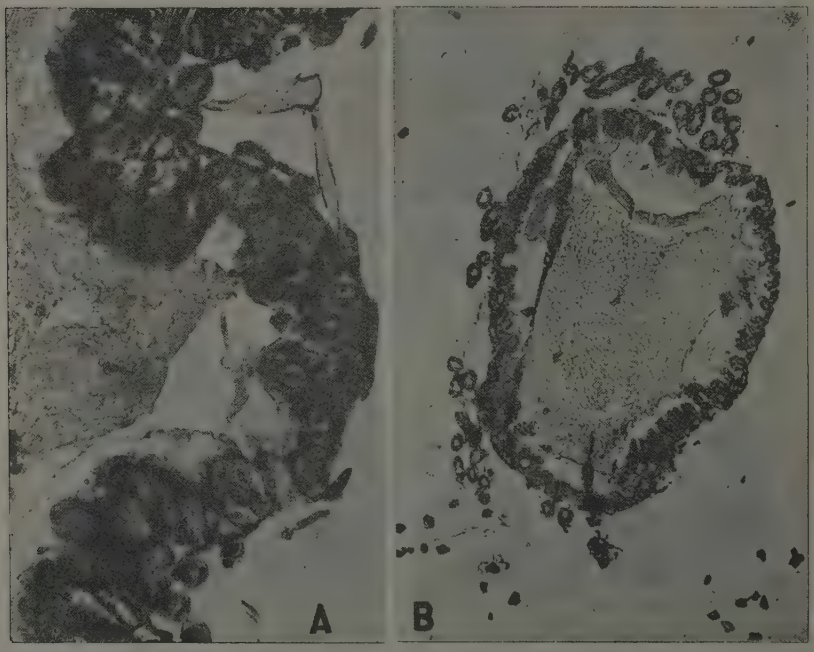

Fig. 5: Longitudinal (A) and transverse (B) sections of the ventriculus of a healthy bee showing epithelial cells and peritrophic membrane.

appear to be club-shaped with thin stalks, as described by Pavlovsky and Zarin (1922). The cells lining the lumen are large and the bases of the outermost cells rest on the basement membrane. The outermost epithelial cells consist of a very fine striated layer, the nuclei of which are usually spherical.

The peritrophic membrane is a noteworthy structure within the ventriculus. In transverse sections it is seen to consist of a series of concentric rings (Fig. 5). Its origin is still undecided and there are two contrasting views.

According to Trappmann (1923), the peritrophic membrane is structureless and is produced by the striated layer of the ventriculus. On the other hand Snodgrass (1925) maintains that the whole striated border of the ventriculus together with its vacuoles, shrinks to form the structureless peritrophic membrane.

A study of the preparations obtained in the investigations being described (Fig. 5) leads to support the conclusion reached by Trappmann (1923), namely that in the case of the worker honey-bee the perotrophic membrane is produced by the striated layer of epithelial cells situated at the anterior

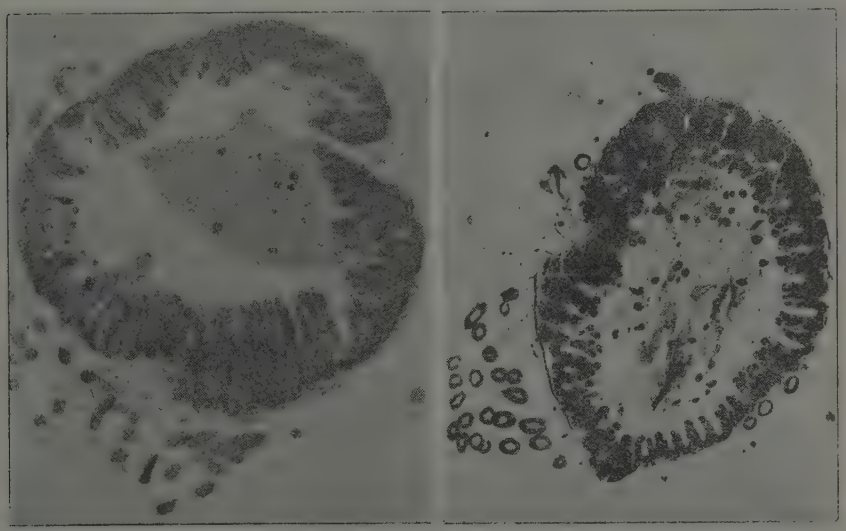

Fig. 6: Transverse sections of the ventriculus and Malpighian tubules of bee infected with *Nosema apis*.

end of the ventriculus. Very frequently as many as five to ten individual peritrophic membranes can be observed, the outermost one being attached to striated cells.

Examinations of the preparations made in the present investigations indicate that the ventriculus of the honey-bee is frequently attacked by *Nosema apis*. This is in accordance with the findings of Zander (1909); Fantham and Porter (1912), White (1919), Hertig (1923), and Morganthaler (1928).

It was found that the first cells to become infected are usually the epithelial cells at the posterior end of the ventriculus. It is, even with the naked eye, fairly easy to distinguish an infected from the uninfected

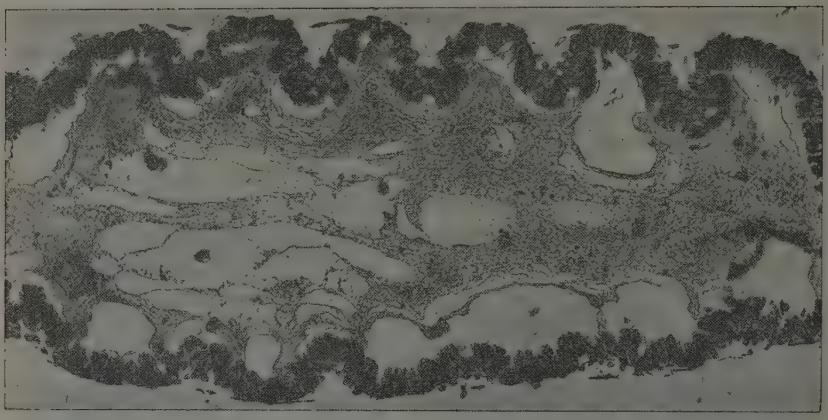

Fig. 7: Longitudinal section of the ventriculus of a healthy bee.

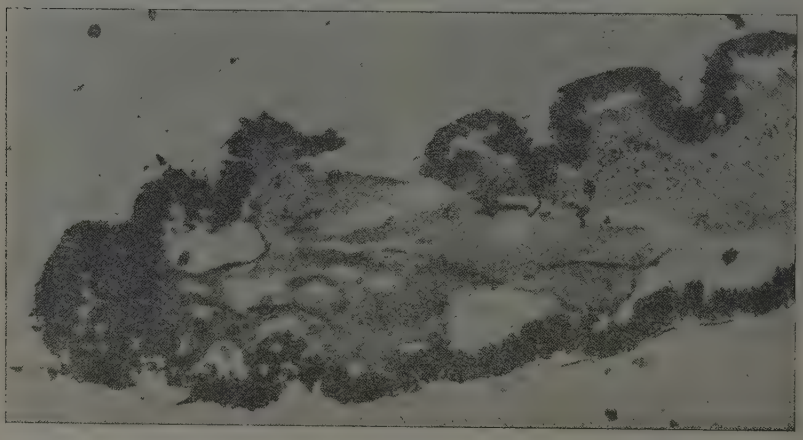

Fig. 8: Longitudinal section of the ventriculus of a bee infected with *Nosema apis* disease.

portion of the mid-gut since the infected area has a chalky appearance whilst the uninfected area retains its normal reddish-brown colour. In the early stages of infection the epithelial cells appear similar to uninfected cells, their size is unchanged and the peritrophic membrane appears normal. At a later stage proliferation of epithelial cells occurs, and this condition

may perhaps be explained by delay in discharge of the secretions of these cells into the lumen of the mid-gut. Small cap-like cells are to be observed covering the ends of some of the epithelial cells (Fig. 4).

In heavily infected portions of the mid-gut the secretory epithelium becomes reduced to a disorganised, ill defined, meshwork of broken down cells enclosing masses of shizonts and spores. The striated border of the mid-gut becomes indistinct and the peritrophic membrane is reduced. The passage of the spores into the lumen of the ventriculus is accompanied by the breakdown of the walls of the cells and frequently the lumen becomes filled with a mass of ruptured epithelial cells, free spores, and cells that have broken free and are filled with a mass of spores (Figs. 4, 6 and 8).

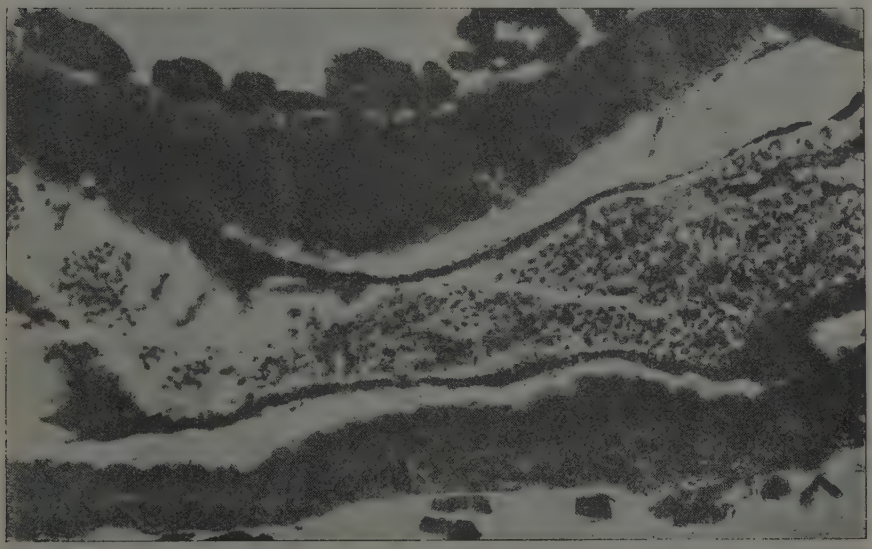

Fig. 9: Longitudinal section in the small intestine of a bee infected with *Nosema apis* disease.

Koeler (1920), who studied the epithelial cells of the ventriculi of bees infected with *Nosema apis*, found that epithelial cells shortly before they disintegrated became filled with masses of spores and the calcium granules which they normally contain had either disappeared altogether or had become greatly reduced in number. She was thus lead to suggest that the pathological effect of the parasite was caused by disturbance of the digestive functions of the ventriculus which led to a calcium deficiency.

The small intestine

The small intestine of the honey-bee consists of a short tube which connects the ventriculus with the hind intestine. The walls of this tube are highly muscular and capable of becoming distended during the passage of food.

At its junction with the ventriculus the epithelial cells of the small intestine are long and narrow and contain rather elongated nuclei. It is at this point that Malpighian tubules join the alimentary canal. Posteriorly the small intestine possesses a well developed intima the cells of which have large round nuclei.

Although of course masses of spores are frequently found filling the lumen of small intestine in the case of bees infected with *Nosema apis*, in no case was any life-history stage of the parasite observed in the epithelial cells of this part of the alimentary canal (Fig. 9).

The Malpighian tubules

The Malpighian tubules of the worker honey-bee consist of about one hundred, long-slender whitish tubes. According to Snodgrass (1925), each tube possesses a single layer of epithelial cells surrounding a thin internal cuticular intima. The inner ends of many of the cells often contain clear spaces and bulge, more or less, into the lumen of the tubule.

In cross section (Fig. 5) it is seen that five or six large cells form the wall of the tube and surround the central lumen. The cytoplasm of each of these cells is granular near its base, and throughout the whole length of each tubule the structure is similar.

According to Green (1931), when secretion occurs a secretory granule (stained black with iron haematoxylin) is formed near the nucleus of a cell on its distal side. This granule migrates towards the free edge of the cell. Simultaneously a clear vesicle develops until it fills that portion of the cell which lies between the nucleus and the cell border.

This vesicle eventually bursts and releases the excretory granules which have migrated into the lumen of the tubule. On being released into the lumen of the Malpighian tubule the secretory granules become irregular in shape and together form a dense mass which gradually moves down into the small intestine.

Examination of preparation of the Malpighian tubules of bees infected with *Nosema apis* shows that the parasite occasionally attacks the cells of the tubules.

Infection of the Malpighian tubules of the honey-bee by *Nosema apis* undoubtedly affects excretion and it seems highly probable that excretion

by the bee is seriously retarded with the result that excretory products accumulate in the blood and may paralyse some of the muscles.

The rectum and rectal glands

The rectum or large intestine forms the last sections of the alimentary canal and terminates in the anus. In general structure the rectum is similar to the honey stomach; the wall is thin and both the inner and outer longitudinal muscle layers are present. That part of the epithelium of the rectum which lies between the rectal glands is much wrinkled. Regularly disposed around the anterior third of the rectum are six glands, the rectal glands.

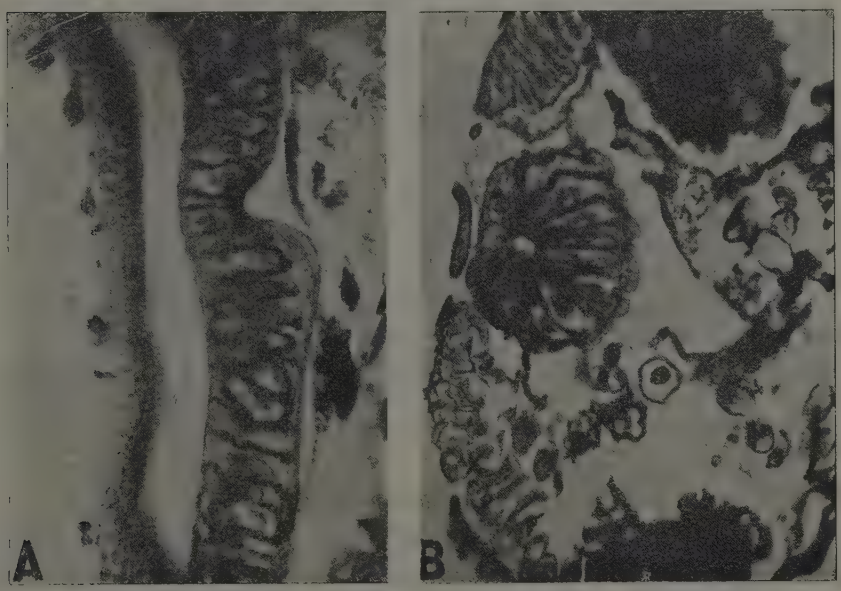

Fig. 10: Longitudinal (A) and transverse (B) sections of the rectum and rectal glands of the worker honey-bee.

According to Pavlosky and Zarin (1922), the rectal galnds are covered by a chitinous cuticle which is formed at the periphery of the organ. Within each gland there is an axial cavity which divides it into two parts, an exterior thin walled and interior walled portion.

The exterior walls are formed of two layers (Fig. 10) and are perforated in some places by trachae which pass into the cavity of the organ.

There are at least two theories as to the function of rectal glands :

(1) Pavlosky and Zarin (1922) suggested that the rectal glands secrete a catalase and that an active oxidising process occurs near them as evidence by their good and intimate tracheal supply.

(2) Wigglesworth (1930) stated that the irregular distributon of rectal glands amongst insects adds to the difficulty of determining their function. He argued that since no disgestive enzymes are secreted into the rectum, and since excretion is carried out by Malpighian tubules, it is probable that the rectal epithelium and its glands are performing the important function of absorbing water from the rectal contents. The observed enlargement of the rectal glands during the winter months when the honey-bee is not flying and water conservation is consequently of prime importance, leads strong support to this view.

CONCLUSIONS

Observations made in the present work produced no evidence to show that *Nosema apis* attacks the cells of the rectum or of the rectal glands. On the other hand it was noted that bees were suffering from *Nosema* disease frequently had their hind-guts greatly distended with a watery fluid and that this was associated with the presence of only rudimentary epithelial cells in the rectum and with poorly developed rectal glands.

It would appear, therefore, that infection of the worker honey-bee by *Nosema apis* has a harmful effect not only on the mid-gut and Malpighian tubules, the cells of which actually become infested with the parasite, but also on the hind gut and rectal glands thus reducing the rate of absorption of water from the rectal contents and leading to dysentery.

ACKNOWLEDGMENTS

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RESULTS OF THE ARMSTRONG COLLEGE EXPEDITION
TO SIWA OASIS (LIBYAN DESERT), 1935,
UNDER THE LEADERSHIP OF PROF. J. OMER-COOPER

Hemiptera-Heteroptera

(with 5 Text-Figures)

by Ludvik Hoberlandt

Hemiptera-Heteroptera collected 14th April to 11th September 1935 by Armstrong College Expedition under the leadership of Prof. J. Cooper to Siwa Oasis contain 58 species and forms in 1246 specimens. The material examined is deposited in the Department of Entomology, British Museum (National History), London.

CYDNIDAE

Aethus pilosulus (Klug, 1845).

1 ♂ : Mersa Matruh, 14.iv.35 ; 1 ♂ : Siwa, 27.v.1935 (light trap).

Widely distributed over the Mediterranean Sub-region, Caucasia, South Russia and Turkestan.

Aethus pallidus (Puton, 1887).

1 ♂ : Mersa Matruh, 14.iv.1935 ; 1 ♂ : Siwa, 27.v.1935 (light trap).

Recorded from Algeria, Morocco, Mauretania and Spanish Sahara.

Cydnus aterrimus (Forster, 1771).

3 ♂♂ and 4 ♀♀ : Mersa Matruh, 14.iv.1935.

Widely distributed over the Mediterranean Sub-region, extending far into Europe, recorded from Caucasia, South and Central Russia, Siberia, also occuring in South Africa, North India and Australia.

Sehirus dubius f. melanoptera (Herrich Schäffer, 1835).

1 ♂ and 1 ♀ : Siwa, 21-22.v., 31.v., and 1.vi.1935.

Recorded from Europe, Siberia, North Africa and South-West Asia.

PENTATOMIDAE

Sciocoris angusticollis Puton, 1885

1 ♀ : El Arig, 7.vi.1935.

Recorded from Algeria.

Stollia inconspicua (Herrich Schäffer, 1844).

6 ♂♂, 9 ♀♀, and 1 nymph : Siwa, 27-28.iv. (sweeping), 21-22.v., 24.v., 26.v., 31.v., 1.vi., 23.vi., 30.vi.1935 ; 2 ♀♀ : Siwa (Zegawa), 13.v.35 ; 1 ♀ : Siwa (Ultabu Tamrahut), 14.v.35 ; 1 ♂ and 1 ♀ : Siwa (Ilrhabit Nachou), 15.v.35 ; 1 ♂ and 1 ♀ : Khamissa, 29.vi.-3.ix.35 ; 1 ♂ and 1 ♀ : Koreishid ; 2 ♂♂ and 1 ♀ : Siwa (Tagzertie), 13.vii.35 ; 2 ♀♀ : Khamissa Depression, 19.vii.35 ; 2 ♂♂ and 2 ♀♀ : Siwa Depression, 22.viii.35.

Recorded from the Mediterranean Sub-region, Iran, Caucasia, South Russia and Turkestan, also occuring in the Ethiopian and Oriental Regions.

Dolycoris numidicus Horváth, 1907.

1 ♀ : Maragi, 14.viii.35.

Recorded from Algeria, Tunisia, Morocco, Tripolitania and Cyrenaica.

Chroantha ornatula (Herrich Schäffer, 1842).

1 ♀ : Siwa, 15.vi.1935.

Widely distributed in the Mediterranean Sub-region, also occuring in Iran, Turkomania and Arabia.

Brachynema virens f. flavomarginata Jakovlev, 1871.

1 ♂ : Siwa, 29.iv.35.

Distributed over the Mediterranean Sub-region, in Caucasia and South Russia.

Acrosternum millieri (Mulsant and Rey, 1866).

1 ♂ and 1 ♀ : Siwa, 24.iv. and 24-28.vii.35 ; 1 ♂ : Siwa (Ilrhabit Nachou), 15.v.35 ; 7 ♂♂ : Gara, 3.vii.35.

Widely distributed over the Mediterranean Sub-region, Turkestan, Turkomania, Iran and Iraq.

Acrosternum heegeri Fieber, 1861.

1 ♀ : Maragi, 24.vi.35 ; 7 ♀♀ : Gara, 3.vii.35 ; 1 ♀ : Siwa Depression (Ain Hammam), 9.vii.35.

Distributed over the Mediterranean Sub-region.

Nezara viridula f. smaragdula (Fabricius, 1775).

1 ♀ : Maragi, 14.viii.35.

Cosmopolitan with exception of cold areas.

Nezara viridula f. torquata (Fabricius, 1775).

1 ♀ : Siwa Depression, Koreishid, Zeitoun (Abu Shruf), 17.v.35 ; 1 ♂ : Siwa Depression (Ain Hammam), 9.vii.35 ; 1 ♂ : Siwa, 16-19.viii.1935.

Cosmopolitan with exception of cold areas.

COREIDAE

Liorhyssus hyalinus (Fabricius, 1794).

1 ♂ and 4 ♀♀ : Khamissa, 29.vi. ; 1 ♀ : 3.ix.35 ; 1 ♂ and 2♀♀ : Siwa (gardens), 18-19.iv.35 ; 3 ♂♂ : Siwa, 22.iv. ; 7 ♂♂ and 3 ♀♀ : 24.iv. ; 1 ♂ and 2 ♀♀ : 29.iv. ; 1 ♂ : 29.iv.-1.v. ; 2 ♂♂ and 2 ♀♀ : 3-5.v. ; 2 ♂♂ and 1 ♀ : 20.v. ; 16 ♂♂, 10 ♀♀ and 3 nymphs : 21-22.v. ; 8 ♂♂ and 2 ♀♀ : 24.v. ; 2 ♂♂ and 1 ♀ : 27.v. ; 1 ♂ and 1 ♀ : 28.v. ; 2 ♂♂ : 30.v. ; 1 ♂ and 1 ♀ : 15.vi. ; 2 ♀♀ : 22.viii. ; 1 ♀ : 22.vi. ; 1 ♂ : 27-28.vi. ; 4♂♂ and 2 ♀♀ : 30.vi. ; 2 ♂♂ and 1 ♀ : 6.vii. ; 1 ♂ and 2 ♀♀ : 11.vii. ; 1 ♂ and 1 ♀ : 16.vii. ; 1 ♂ : 16-17.vii. ; 1 ♀ : 20-21.vii. ; 1 ♀ : 1.viii. ; 1 ♂ : 6.viii. ; 2 ♂♂ : 13.viii. ; 1 ♂ : 19.viii. ; 2 ♀♀ : 21.viii. ; 2 ♀♀ : 22.viii. ; 1 ♂ : 4.ix. ; 1 ♂ and 3 ♀♀ : 6.ix. ; 2 ♀♀ : 8.ix.1935 ; 1 ♀ : Siwa Depression, 15.vii. ; 3 ♂♂ : 20-21.vii.1935 ; 1 ♂ and 2 ♀♀ : Siwa Zegawa, 13.v.35 ; 1 ♂ and 4 ♀♀ : Siwa (Ilrhabit Nachou), 15.v.1935 ; 1 ♀ : El Arig, 8.vi.1935 ; 3 ♂♂ and 4 ♀♀ : Baharein, 11.vi.35 ; 1 ♀ : Koreishid, 30.vi.1935 ; 2 ♂♂ and 4 ♀♀ : Gara, 3.vii. ; 4 ♂♂ and 1 ♀ : 4.vii.1935 ; 1 ♂ : between Gara and Siwa, 5.vii.1935 ; 2 ♂♂ : Khamissa Depression, 19.vii.1935 ; 1 ♂ and 2 ♀♀ : Maragi, 14.viii.1935.

Cosmopolitan with exception of cold areas.

Liorhyssus hyalinus f. sanguinea (Costa, 1852).

1 ♀ : Siwa, 20.iv.1935 (evening sweeping).

Distribution similar to that of typical form.

Liorhyssus hyalinus f. pallida Mancini, 1935.

1 ♂ and 2 ♀♀ : Siwa, 24.iv.35 (evening sweeping) ; 1 ♂ : Gara, 2.vii.1935.

Recorded from Fezzan.

Liorhyssus hyalinus f. marginata (Jakovlev, 1871).

1 ♂ and 2 ♀♀ : Siwa, 18-19.iv. (gardens) ; 1 ♀ : 20.iv. (evening sweeping) ; 1 ♀ : 24.v. ; 1 ♂ : 6.vii. ; 1 ♀ : 21.viii.1935 ; 1 ♀ : Khamissa, 3.ix.1935.

Recorded from Caucasia and South Russia.

LYGAEIDAE

Lygaeus pandurus (Scopoli, 1763).

1 ♀ : Siwa, 26.v. ; 3 ♂♂ : 21.vii. ; 1 ♀ : 22.viii.1935 ; 1 ♀ : Baharein, 9-10.vi. ; 2 ♀♀ : 11-12.vi.1935.

This species extends throughout the subtropical and tropical regions of the Eastern Hemisphere.

Nysius cymoides (Spinola, 1837).

1 ♂ and 2 ♀♀ : 18-19.iv. (gardens) ; 1 ♂ : 29.iv.-1.v. ; 1 ♀ : 10.v. ; 1 ♀ : 12.v. ; 1 ♀ : 21-22.v. ; 2 ♂♂ : 24.v. ; 1 ♂ : 25.v. ; 5 ♀♀, 27.v. (light trap) ; 2 ♂♂ and 1 ♀ : 28.v. ; 2 ♂♂ : 29-30.v., 1 ♀ : 30.v. ; 1 ♂ : 22.vi. ; 1 ♂ : 24-28.vi. ; 2 ♀♀ : 29.vi. ; 5 ♂♂ and 2 ♀♀ : 30.vi. ; 1 ♂ : 15.vii. ; 2 ♀♀ : 20.vii. ; 1 ♂ : 23.vii. ; 1 ♂ : 4.viii. ; 2 ♂♂ and 1 ♀ : 9.viii. ; 2 ♂♂ and 2 ♀♀ : 13.viii. ; 2 ♀♀ : 15.viii. ; 1 ♂ : 28.viii. ; 2 ♂♂ and 1 ♀ : 31.viii. ; 1 ♀ : 2.ix. ; 1 ♀ : 4.ix. ; 1 ♀ : 6.ix. ; 1 ♀ : 8.ix.1935 ; 2 ♀♀ : Siwa (Zegawa), 8.v. ; 1 ♂ : 13.v.1935 ; 1 ♀ : Siwa (Ultadu Tamrabut), 14.v.1935 ; 1 ♂ and 4 ♀♀ : Siwa (Ilrhabit Nachou), 15.v.1935 ; 1 ♂ and 1 ♀ : Khamissa, 29.vi. ; 1 ♂ and 1 ♀ : 28.viii.1935 ; 2 ♀♀ : Gara, 4.viii.1935 ; 1 ♂ and 3 ♀♀ : Siwa (Tagzertie), 13.vii.1935 ; 1 ♂ : Maragi, 14.viii.1935.

Widely distributed over the Mediterranean Sub-region, extending far into Central Europe, recorded from Caucasia and Turkestan.

Piocoris luridus (Fieber, 1844).

1 ♂ : Siwa, 16.vii. ; 1 ♂ : 15.viii.1935.

Recorded from Anatolia, Iran, Arabia, the Sudan, Egypt and North Africa.

Geocoris nigriceps f. henoni Puton, 1892.

1 ♀ : Siwa, 16.vii.1935.

Recorded from Egypt, Tripolitania, Morocco and Central Sahara.

Artheneis aegyptiaca Lindberg, 1939.

3 ♀♀ : Siwa, 15.viii.1935.

Recorded from Egypt and Cyrenaica.

Camptocera horvathi Jakovlev, 1877.

1 ♂ : Siwa, 26.v. ; 2 ♀♀ : 30.vi. ; 1 ♂ and 3 ♀♀ : 20.vii. ; 4 ♂♂ and 4 ♀♀ : 5.viii. ; 3 ♂♂ and 5 ♀♀ : 6.viii. ; 1 ♂ and 3 ♀♀ : 9.viii. ; 1 ♂ : 24.viii. ; 2 ♂♂ : 25.viii.1935 ; 1 ♂ : Siwa (Tutnatee), 25-26.vi.1935 ; 1 ♀ : Khamissa, 29.vi.1935 ; 20 ♂♂ and 15 ♀♀ : Siwa Depression, 30.vi.1935.

Recorded from Spain, Italy, Sicily, Algeria, Libya, Anatolia, Syria, Caucasia, South Russia, Turkestan, Buchara, Punjab, Central and South India.

REDUVIIDAE

Oncocephalus fasciatus Reuter, 1882.

1 ♂ : Siwa, 25.v. : 1 ♂ : 21.vii.1935.

Recorded from the Sahara, South Algeria and Morocco.

Oncocephalus fokkeri Horváth, 1896.

1 ♂ : Siwa, 28.v. ; 2 ♂♂ : 20-21.vii. ; 2 ♂♂ : 21.vii. ; 1 ♂ : 21-22.vii. ; 1 ♂ : 6.viii.1935.

Recorded from Algeria.

Reduvius pallipes (Klug, 1830).

1 ♂ and 1 ♀ : Siwa, 22.vi. ; 1 ♂ : 30.vi. ; 1 ♂ : 7.viii. ; 1 ♂ : 2.ix.1935 ; 1 ♂ : Khamissa, 28.viii.1935.

Recorded from Egypt, Greece, Sicily, Yugoslavia, Rhodos, Cyprus, Libya, Anatolia, Iran, Syria, Iraq, Baluchistan, Turkestan and Arabia.

Reduvius jakovlevi Reuter, 1892.

3 ♂♂ : Siwa, 9.vii. ; 1 ♂ : 9.viii. ; 1 ♀ : 10.viii. ; 1 ♀ : 25.viii. ; 1 ♀ : 27.viii. ; 1 ♂ and 3 ♀♀ : 1.ix.1935.

Recorded from Syria and Cyprus.

Reduvius minutus (Reuter, 1881).

2 ♂♂ : Siwa, 25.viii.1935 ; 1 ♂ : Siwa Depression (Zeitoun), 2.ix.1935.

Recorded from Egypt, Tunisia and Sicily.

Vachiria natolica Stal, 1859.

1 ♀ : Siwa, 31.vii. ; 1 ♀ : 4.ix.1935.

Recorded from Anatolia, Egypt, Algeria, Cyrenaica and Spain.

Coranus aegyptius (Fabricius, 1775).

1 ♂ : Gara, 4.vii.1935 ; 1 ♂ : Maragi, 14.viii.1935 ; 1 ♂ : Siwa, 21.viii.35.

Widely distributed over the Mediterranean Sub-region, extending far into Central Europe and occuring also in Caucasia, South Russia and Turkestan.

NABIDAE

Nabis (Nabis) capsiformis (Germar, 1837).

1 ♂ : Siwa, 18.iv. ; 5 ♂♂ and 3 ♀♀ : 18-19.iv. (gardens) ; 1 ♂ : 20.iv. (evening sweeping) ; 3 ♂♂ and 2 ♀♀ : 22.iv. (nocturnal and on *Tamarix* spec.) ; 4 ♂♂ and 2 ♀♀ : 24.iv. (evening sweeping) ; 14 ♂♂ and 4 ♀♀ : 29.iv. (evening sweeping) ; 1 ♀ : 29.iv.-1.v. ; 1 ♂ : 29.iv.-4.v. (moth trap) ; 2 ♂♂ and 1 ♀ : 3-5.v. ; 4 ♂♂ and 5 ♀♀ : 12.v. ; 1 ♂ and 1 ♀ : 20.v. ; 5 ♂♂ and 3 ♀♀ : 21-22.v. ; 1 ♂ : 29.v. ; 1 ♂ : 6.vii. ; 1 ♀ : 19.vii.1935 ;

1 ♂ and 1 ♀ : Zegawa ; 1 ♂ and 1 ♀ : 13.v.1935 ; 1 ♂ and 2 ♀♀ : Siwa (Ilrhabit Nachou), 15.v.1935 ; 1 ♀ : Baharein, 11.vi.1935.

Cosmopolitan, except in cold countries.

CIMICIDAE

Cimex lectularius Linnaeus, 1758.

23 ♂♂, 39 ♀♀ and 14 nymphs ; Siwa, 2.ix.1935.

Cosmopolitan.

ANTHOCORIDAE

Orius albidipennis (Reuter, 1884).

1 ♂ : Siwa, 24.iv. (evening sweeping) ; 2 ♀ : 29 iv. (evening sweeping) ; 4 ♂♂ and 10 ♀♀ : 29.vi.-1.v. ; 9 ♀♀ : 12.v. ; 1 ♂ and 1 ♀ : 21-22.v. ; 1 ♀ : 23.v. (moth trap) ; 2 ♀♀ : 24.v. ; 10 ♀♀ : 29-30.v. ; 2 ♀♀ : 30.vi. ; 1 ♀ : 7.vii. ; 1 ♀ : 20-21.vii. ; 16 ♀♀ : 7.viii. ; 1 ♀ : 9.viii. ; 2 ♂♂ and 3 ♀♀ : 13.viii. ; 1 ♂ and 1 ♀ : 14.viii. ; 2 ♂♂ and 2 ♀♀ : 31.viii. ; 1 ♂ : 9.ix.35 ; 2 ♂♂ : Siwa (Zegawa), 8.v. ; 3 ♂♂ and 5 ♀♀ : 13.v.1935 ; 1 ♀ : Ilrhabit Nachou, 10.v.1935 ; 1 ♀ : Maragi, 14.viii.1935.

Recorded from Egypt, North Africa, Canary Islands, Israel, Iraq, Turkestan and occuring also in the Ethiopian Region.

Most specimens from Siwa Oasis are very variable in colour and the light-coloured specimens agree with those which I have seen from Northern Iraq (*Acta ent. Mus. Nat. Pragae*, 1949, XXVI, 360 : 9).

Orius pallidicornis (Reuter, 1884).

1 ♀ : Siwa, 28.viii.1935 ; 1 ♂ and 3 ♀♀ : Siwa Depression, 1935.

Recorded from Corsica, Sicily and Tunisia.

Xylocoris (Xylocoris) galactinus (Fieber, 1836).

1 ♂ and 1 ♀ : Siwa, 5.ix.1935.

Widely distributed over Europe, North Africa, South-West Asia, occurs in Central and South Russia and Caucasia. Recorded also from North and Central America.

MIRIDAE

Creontiades pallidus (Rambur, 1842).

3 ♀♀ : Siwa, 24.iv. (evening sweeping) ; 3 ♂♂ and 8 ♀♀ : 29.iv. (evening sweeping) ; 2 ♂♂ and 2 ♀♀ : 3-5.v. ; 2 ♀♀ : 21-22.v. ; 1 ♂ : 22.vi.1935 ; 1 ♂ and 1 ♀ : Siwa Depression, 20-21.vii.1935 ; 1 ♂ : Zegawa, 8.v. ; 1 ♀ : 13.v.1935.

Widely distributed over the Mediterranean Sub-region and recorded from the Sudan, Togo, Arabia and Madagascar.

Creontiades pallidus f. reuteriana (Fairmaire, 1885).

1 ♂ : 18-19.iv. (gardens) ; 1 ♀ : 20.iv. (evening sweeping) ; 1 ♂ and 2 ♀♀ : 24 iv. (evening sweeping) ; 4 ♂♂ and 1 ♀ : 3-5.v. ; 1 ♂ : 12.v. ; 1 ♂ : 13.v. ; 1 ♂ and 2 ♀♀ : 24.v. ; 1 ♂ : 21-22.v. ; 1 ♀ : 22.vi. ; 2 ♂♂ : 30.vi. ; 1 ♂ and 1 ♀ : 7.vii. ; 1 ♂ and 1 ♀ : 16-17.vii. ; 3 ♂♂ and 1 ♀ : 17.vii. ; 1 ♂ and 1 ♀ : 18.vii. ; 1 ♂ and 1 ♀ : 21-22.vii. ; 1 ♀ : 24.vii. ; 1 ♀ : 25.vii. ; 1 ♂ and 1 ♀ : 26.vii. ; 2 ♀♀ : 29.vii. ; 1 ♂ and 1 ♀ : 6.viii. ; 1 ♂ : 7.viii. ; 2 ♂♂ and 1 ♀ : 9.viii. ; 2 ♂♂ and 1 ♀ : 16-17.viii. ; 1 ♂ and 1 ♀ : 21.viii. ; 1 ♂ : 24.viii. ; 10 ♀♀ : 28.viii. ; 1 ♀ : 31.viii. ; 1 ♀ : 2.ix. ; 1 ♂ : 6.ix. ; 1 ♂ and 3 ♀♀ : 8.ix.1935 ; 1 ♂ : Siwa (Zegawa), 13.v.1935 ; 1 ♀ : Siwa Depression, 12.viii. ; 1 ♀ : 20-21.vii.1935 ; 2 ♂♂ : Gara, 4.vii.1935 ; 1 ♀ : Siwa (Tagzertie), 13.vii.1935 ; 3 ♂♂ and 1 ♀ : Maragi, 14.viii.1935 ; 1 ♂ : Khamissa, 3.ix.1935.

Distribution same as the typical form.

Eurystylus bellevoyei (Reuter, 1879).

1 ♀ : 16.vii. ; 1 ♂ : 20-21.vii. ; 1 ♀ : 29.vii. ; 1 ♂ : 9.viii. ; 1 ♀ : 2.ix. 1935 ; 1 ♀ : Siwa Depression, 20-21.vii.1935.

Recorded from Egypt, Algeria, Iran and Turkomania. Occurs in the Ethiopian Region.

Lygus (Apolygus) apicalis Fieber, 1861.

1 ♀ : Siwa, 29.iv.1935.

Widely distributed over the Mediterranean Sub-regoin. Occuring also in South China, Ethiopian, Nearctic and Neotropic Regions.

Cyrtopeltis (Nesidiocoris) tenuis (Reuter, 1895).

1 ♀ : 16.vii. ; 1 ♂ : 20-21.vii. ; 1 ♀ : 29.vii. ; 1 ♂ : 9.viii. ; 1 ♀ : 2.ix.1935 ; 1 ♀ : Siwa Depression, 20-21.vii.1935.

Recorded from Egypt, Libya, Algeria, Tunisia, Morocco, Madeira, Canary Islands, the Sudan, China and South India.

Linoceraea lunigera Horváth, 1913.

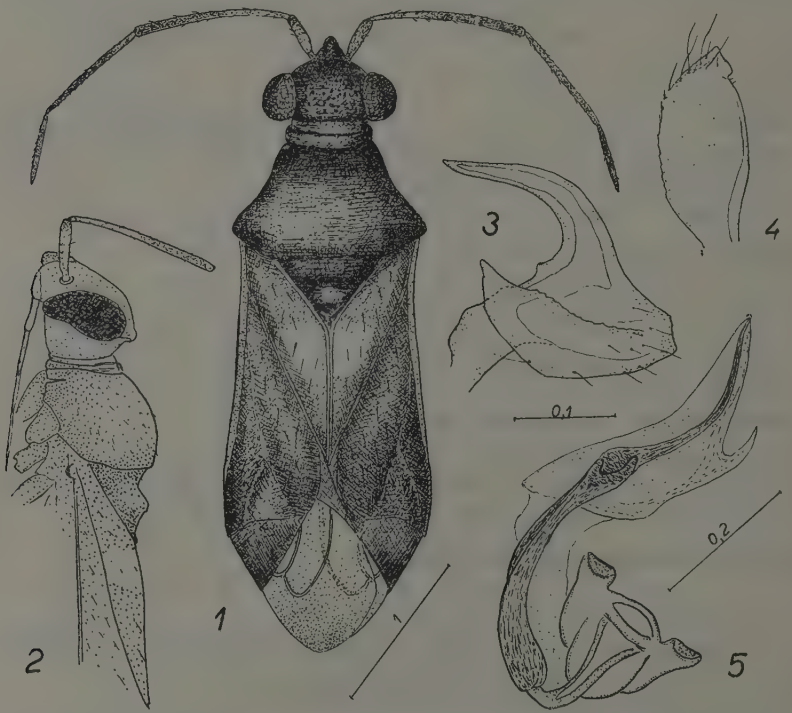
1 ♂ : Siwa, 2.ix.1935.

This species is recorded only from Central Sahara (G. Horváth : *Novitates Zoologicae*, XX : 596-597, 1913).

The genus *Linoceraea* Horváth is allied to *Laemocoris* Reuter, *Trachelonotus* Reuter and *Cyrtopeltocoris* Reuter and may be distinguished by the characters mentioned in the following redescription of the species.

Male (Figs. 1 and 2) : General colour reddish or fuscous brown, strongly shiny and with a whitish pattern on clavus. Head blackish brown, on vertex rather brownish or reddish, jugum and lorum reddish ; eyes blackish, rostrum brownish with base and apices of respective joints slightly paler. Antennae

brown with base and apex of first joint infuscated, distal half of second joint blackish; antennae with short subappressed golden shiny pubescence. Pronotum reddish to fuscous brown, only the frontal third brownish and on disc slightly paler. Scutellum brown with a reddish shade. Sternum brown, posterior acetabula pale. Hemielytra fuscous brown, inner posterior angle of corium especially dark; embolium more or less paler; clavus beyond the



Linoceraea lunigera Horvath, male:

Fig. 1: General aspect. — Fig. 2: Lateral aspect of head, pronotum and scutellum. — Fig. 3: Left clasper. — Fig. 4: Right clasper. — Fig. 5: Penis.

middle of its length with a transversal white stripe, occupying nearly one fourth of the length of clavus, towards the middle slightly widened and crossing the middle longitudinal commissure of hemielytra; cuneus fuscous brown, membrane greyish-brown. Abdomen fuscous brown, anterior margin of respective ventrites with a reddish shade. Body and hemielytra strongly shiny, with sparse pale pubescence, rather long and erect on hemielytra. Femora and tibiae fuscous, base of femora pale, posterior third of tibiae

brown, tarsi pale brown. Legs with sparse pale pubescence, on apices of tibiae rather longer and more erect and tibiae with some longer bristles.

Head short, slightly longer than two thirds of the head width across the eyes (16 : 21), in the front of eyes narrowed and strongly deflected, vertex moderately convex, broad nearly the half of the head width across the eyes (10 : 21), posterior margin of vertex with a high transverse ridge extending from eye to eye ; tylus moderately elongated and distinctly separated, the base of the tylus at the level of the base of antennae ; eyes large, strongly convex, distinctly wider than half their length (5.5 : 9). Surface of the head sparsely and finely rugulosely punctate. Antennae rather thick, first antennal joint nearly cylindrical at base, slender, its distal half projecting beyond the apex of the tylus, second joint long, towards the apex slightly widened, third and fourth joints of the same thickness. Relative lengths of antennal joints I : II : III : IV : : 8 : 26 : 18 : 13. Rostrum slender, reaching to the end of middle coxae. Pronotum moderately convex, disc rather flattened, distinctly longer than wide at base (28 : 21), towards the apex strongly narrowed (anterior margin nearly 2,5 times shorter than basal margin, 11 : 28), lateral margins of pronotum sinuate, humeral angles narrowly rounded, basal margin at the level of the scutellar base truncate, anterior margin constricted into a narrow collar. Pronotal surface with very dispersed shallow irregular punctuation and sparse pale subapressed pubescence, pronotal collar transversally rastrated. Scutellum one third longer than wide (16 : 10), the posterior half moderately developed into a vertical obtuse cone, mesoscutum moderately exposed ; surface of scutellum smooth and shiny. Hemielytra in the basal third slightly narrowed ; embolium narrow, cuneus with rather indistinct fracture ; clavus slightly arched, chiefly in posterior part. Hemielytra smooth and strongly shiny with dispersed pale long erect hairs. Sternum and venter finely sculptured, with sparse pubescence. Legs slender and long. Relative lengths of posterior leg, femur : tibia : tarsus 1 : tarsus 2 : tarsus 3 : : 30 : 47 : 5 : 5 : 5,5 : 6.

Left clasper (Fig. 3) with two long acute points almost perpendicular to one another. Right clasper (Fig. 4) semi-oval with one tooth near the apex. Bith claspers with sparse bristles. Penis as in Figure 5.

Length, 3.5-3.6 mms. ; width across humeral angles, 1.06 mm., on base of cuneus, 1.18 mm.

Orthotylus pusillus Reuter, 1883.

1 ♀ : Siwa, 6.viii.1935.

Recorded from Tunisia and Morocco.

Orthotylus spp.

14 specimens : Siwa, 22.vii., 29.vii., 9.viii., 24 and 26.viii., 1.ix.1935 ; Khamissa, 29.vi. and 5.viii.1935 ; Maragi, 26.viii.1935.

These specimens belong to *Orthotylus* but I am unable to identify them with any of the known species of the genus. I do not propose to establish any new species, as all specimens are teneral.

Megalocoleus chrysotrichus (Fieber, 1864).

1 ♂ : Siwa Depression (Zeitoun), 2.ix.1935.

Recorded from Greece, Roumania, South Russia, Caucasia and Turkestan.

Megalocoleus sp.

2 specimens : Siwa, 6.viii.1935, and Siwa (Tutnatee), 28.vi.1935.

As both specimens are teneral I am unable to identify them.

Psallus sp.

2 specimens: Siwa, 30.vi.1935, and Siwa (Tutnatee), 28.vi.1935.

Teneral specimens.

Plagiognathus sp.

3 specimens : Siwa, 30.vi.1935, and 22.vii.1935.

All specimens are teneral and I am unable to identify them.

Campylomma nicolasi Puton and Reuter, 1893.

1 ♂ : Siwa, 12.v. ; 2 ♂♂ : 6.vii. ; 2 ♂♂ : 21.viii. ; 1 ♂ : 8.ix.1935 ; 1 ♂ : Maragi, 14.viii.1935.

Recorded from South France, Egypt and Tauria.

Campylomma annulicornis (Signoret, 1865).

1 ♀ : Khamissa, 5.viii.1935.

Recorded from Italy, France, the Balkans, South Russia, Caucasia and Turkestan.

Campylomma diversicornis Reuter, 1878.

1 ♀ : Siwa, 13.viii.1935.

Recorded from Greece, Iran and Turkestan.

Campylomma angustula Reuter, 1904.

1 ♂ : Siwa, 22.vi. ; 2 ♂♂ and 1 ♀ : 6.vii. ; 2 ♂♂ : 7.vii. ; 1 ♀ : 19.vii. ; 1 ♂ : 23.vii. ; 1 ♂ : 5.viii. ; 2 ♂♂ and 3 ♀♀ : 7.viii. ; 1 ♂ and 6 ♀♀ : 9.viii. ; 2 ♂♂ : 13.viii. ; 1 ♂ : 15.viii. ; 1 ♂ : 20.viii. ; 2 ♂♂ and 2 ♀♀ : 21.viii. ; 2 ♀♀ : 24.viii. ; 3 ♂♂ and 2 ♀♀ : 31.viii. ; 3 ♂♂ and 1 ♀ : 6.ix.1935 ; 1 ♂ and 1 ♀ : Siwa Depression, 12.vii. ; 1 ♀ : 20-21.vii.35 ; 4 ♂♂ and 1 ♀ : Gara, 4.vii.1935 ; 1 ♂ : Jagub, 18-19.viii.1935.

Recorded from Egypt and Central Sahara.

Auchenocrepis alboscutellatus Puton, 1874.

7 ♂♂ and 3 ♀♀ : Siwa, 28.v. ; 1 ♀ : 1.vi. ; 2 ♂♂ : 11.vii. ; 1 ♂ :

16.vii. ; 1 ♂ and 1 ♀ : 20-21.vii. ; 2 ♂♂ and 2 ♀♀ : 9.viii.1935 ; 3 ♂♂ and 1 ♀ : El Arig, 8.vi.1935 ; 1 ♂ and 2 ♀♀ : Maragi, 24.vi.1935 ; 1 ♂ : Tutnatee, 25-26.vi.1935.

Recorded from Egypt, Libya, Algeria, Tunisia, Morocco, Spain, Iran and Cyprus.

Tuponia pallida Reuter, 1878.

1 ♂ : Siwa, 30.vii.1935.

Recorded from Turkestan.

Tuponia elegans (Jakovlev, 1867).

1 ♂ and 1 ♀ : Siwa, 21.vii. ; 1 ♂ : 14.viii. ; 9 ♂♂ and 6 ♀♀ : 15.viii. ; 1 ♀ : 20.viii. ; 1 ♂ : 2.ix. ; 6 ♂♂ and 3 ♀♀ : 3.ix.1935.

Recorded from Algeria, Caucasia, Armenia, South Russia and Turkestan.

Tuponia hippophaës (Fieber, 1861).

1 ♂ : Siwa, 11.vii. ; 1 ♂ : 16.vii. ; 1 ♂ : 13.viii.1935.

Widely distributed over the Mediterranean Region.

Tuponia sp.

8 specimens : Siwa, 29.vii., 15.viii.1935 ; Zeitoun, 27-30.viii.1935 ; Tutnatee (Redunkalil), 6.ix.1935.

As the specimens are teneral I am unable to identify them.

Eurycranella geocoriceps Reuter, 1904.

1 ♂ : Siwa (Tutnatee), 28.vi.1935 ; 1 ♂ : Khamissa, 29.vi.1935 ; 1 ♂ : Siwa, 9.viii.1935.

Recorded from Egypt.

SALDIDAE

Saldula pallidipennis (Reuter, 1888).

1 ♂ : Siwa Depression, 20.iv. ; 1 ♂ and 1 ♀ : 25.iv.1935 ; 1 ♂ : Siwa, 29.iv.-4.v.1935 (moth trap).

Distributed over the Mediterranean Sub-region, occurring also in Caucasia and South Russia.

MESOVELIIDAE

Mesovelia vittigera Horváth, 1895.

2 ♂♂ : Siwa Depression, 20.iv. ; 4 ♀♀ : 22.iv.1935 ; 3 ♂♂, 1 ♀, and 1 nymph : Siwa Depression (Ultabu Tamrabut), irrigation pool, 14.v.1935 ; 3 ♂♂, 2 ♀♀, and 1 nymph : Siwa Depression (Ilrhabit Uncorde), 18.v.1935 ; 4 ♀♀ : Siwa, 22-27.iv. ; 1 ♂ : 7.vi.1935. *Apterous forms.*

Widely distributed in tropical and North Africa, occurring also in South France, Albania, Anatolia, Syria and Israel.

NOTONECTIDAE

Anisops canariensis perplexa Poisson, 1929.

1 ♂ : Siwa Depression, 20.iv.1935 ; 6 ♂♂ and 6 ♀♀ : Siwa Depression (Ultabu Hirfala), 25.viii. ; 6 ♂♂ and 7 ♀♀ : 10.v.1935 ; 3 ♂♂ : Siwa, 28.iv. ; 5 ♀♀ : 28.viii.1935 ; 4 ♂♂ and 1 ♀ : Gara, 2.vii.1935 ; 1 ♂ : Girba, 12.viii.1935.

Recorded from Central Sahara.

CORIXIDAE

Heliocorisa vermiculata (Puton, 1874).

11 ♂♂ and 20 ♀♀ : Gara, 3.vii.1935 ; 2 ♂♂ and 5 ♀♀ : Girba, 12.viii.1935.

Distributed over North Africa, South Spain, Turkey (?), Transcaucasia and Iran.

Sigara (Halicorixa) selecta (Fieber, 1848).

2 ♂♂, 3 ♀♀, and 3 nymphs : Siwa Depression (Redunkalil, Tutnatee), 12.v. : 2 ♂♂, 1 ♀, and 1 nymph : 13.v. ; 1 ♂ : 12.ix.1935 ; 1 ♂ and 3 ♀♀ : Siwa Depression, 18.v.1935 ; 24 ♂♂ and 36 ♀♀ : Siwa Depression (Anas Yutra), 3.ix.1935, 1 ♀ : Siwa Depressin (Ultabu Teayda), 16.vii.1935 ; 5 ♂♂, 14 ♀♀, and 5 nymphs : Siwa, 20.v. ; 1 ♂ : 3.ix.1935 ; 1 ♀ : Girba, 12.viii.1935 ; 2 ♀♀ : Siwa (Khamissa), 29.vi. ; 4 ♂♂ and 14 ♀♀ : 3.ix.1935.

Distributed over the Mediterranean Sub-region, England, France, Austria, Hungary and Germany.

Sigara (Vermicorixa) lateralis lateralis (Leach, 1818).

1 ♂, 1 ♀, and 1 nymph : Siwa Depression, 20.iv. ; 1 ♂ : 22.iv. ; 14 ♂♂, 32 ♀♀, and 14 nymphs : 25.iv. ; 1 ♀ and 1 nymph : 18.v. ; 1 ♂ and 1 ♀ : 26.v. ; 4 ♂♂ : 4.vii.1935 ; 3 ♂♂ and 2 ♀♀ : Siwa Depression (Ain Hammam), 9.vii.1935 ; 1 ♂ and 1 ♀ : Ilrhabit Uncorde, 18.v.1935 ; 1 ♂ : Siwa, 28.viii.1935.

Widely distributed over Europe, North Africa and South-West Asia.

Biological observations on *Polistes gallicus* L. and *Polistes foederata* Koch, with special reference to stylopization

[Hymenoptera : Vespidae-Polistinae]

(with 8 Text-Figures and 9 Tables)

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I. INTRODUCTION

Polistes wasps usually occur in great abundance in the vicinity of buildings, barns and neglected places in our villages. Following out the population density of our most common species, viz. *Polistes gallicus* L. and *P. fœderata* Kohl, during the summer and autumn of 1950, winter and spring of 1951 and 1952, it has been found that it reaches its peak in the first half of September, decreases gradually with the approach of winter and reaches its minimum level in December and January. The active broad-rearing season begins generally in March, but nest building activities does not stop during the winter months. Whenever the weather gets warm and sunny hibernating

queens can be seen on the wing and they can start building their nests without undergoing a long period of hibernation. Any warm spell during the winter will induce the queens to come out of their hibernating places to start brood-rearing. During this particular period queens start building their nests in holes or on walls in places facing south or east irrespective of whether they are protected from the sun or not ; in such places temperature may rise on sunny days to any degree between 23 and 31.5° C. In December 1950, January and February 1951 and 1952 some newly built nests were encountered. These nests were built up and eggs were laid in by foundresses but none of them maintained nest-building activities through the active season. Cold spells were found to bring this social behaviour to a complete cessation, for nests were abandoned and hatching larvae dead. On one occasion very advanced pupae were met with in the middle of January.

Polistes wasps, therefore, respond quickly to temperature changes ; in winter it requires only a short duration of warmth to call forth all components of maternal instinctive behaviour, namely : nest building, egg-laying, storing honey, feeding the larvae and soforth, but a drop in temperature will bring this activity to a temporary cessation and if it remains cold for a longer period foundresses will break the chain of their instinctive behaviour and resort to hibernation.

II. THE ECONOMIC POSITION OF POLISTES WASPS

Polistes wasps are far from being agricultural pests. Inspite of the scarcity of available literature at one's disposal so many records have been found which indicate that they attack several hosts some of which are serious pests. *P. annularis* L., for instance, controls the cotton-worm, *Alabama argillacea* Hb., in St. Vincent to such an extent that for 10 years Paris green and other insecticides were not used (Ballou, 1934). The feeding of *Polistes* larvae by queens when the nest is in its incipient stage and by workers when they emerge with pellets made of malaxated portions of caterpillars, flies or other insects has been often described and can be readily witnessed in any colony kept in the laboratory. In the present work colonies of *P. fœderata* and *P. gallicus* were offered different sorts of plant feeding caterpillars. Workers were found to attack and chew them, mix them with their copious secretion of their salivary glands ; and when the workers moulded them into soft round bodies by the use of their mandibles and front legs, the pellets were handled over to the hungry larvae which protruded their heads with open mouths from the orifices of the cells. Several host larvae were used as food and it seems that *Polistes* wasps do not attach themselves to any particular host. The following is a list of hosts used as food by colonies kept in the laboratory, and it may be observed that some

of them are never encountered by wasps in the field as they spend their vulnerable stages hidden in the stems of some trees.

HOST	STAGED USED AS FOOD
Prodenia litura F.	Advanced larval stage.
Plusia sp.	Advanced larval stage.
Achroia grisella F.	Fully grown larvae.
Chloridea obsoleta F. (=*armigera* Hubn.).	Second and third stage larvae.
Synanthedon myopaeformis Borkh.	Fully grown larvae.
Zeuzera pyrina L.	Young stage larvae.
Chilo simplex But.	Advanced larval stage.
Pyrausta nubilalis Hb.	Young stage larvae.
Earias insulana Boisd.	Advanced larval stage.

Moreover the following list which contains 15 species of *Polistes* and their corresponding hosts was compiled from the available literature, and it will be seen that these cosmopolitan wasps are useful predators attacking so many agricultural pests in several parts of the world.

POLISTES SPECIES	HOSTS	LOCALITIES	REFERENCES
canadensis L.	*Schematiza cordiae*	Trinidad	Simmonds, 1948
canadensis L.	*Laphygma frugiperda*	U.S.A.	Hinds, 1915
canadensis L.	*Mocis repanda*	Trinidad	Urich, 1915
canadensis L.	*Alabama argillacea*	Trinidad	Urich, 1915
canadensis L.	*Icerya brasiliensis*	Paraguay	Bertoni, 1924
canadensis L.	*Datana intergerrima*	U.S.A.	Hixon, 1941
macaensis F.	*Pyrausta phoenicealis*	Seychelles	Fitzgerald, 1936
macaensis F.	*Dichomeris ianthes*	Seychelles	Fitzgerald, 1936
macaensis F.	*Earias fabia*	Fiji	Simmonds, 1928
macaensis F.	*Chloridea obsoleta* (=*armigera* Hubn.)	Fiji	Lever, 1940
macaensis F.	Caterpillars, flies, grasshoppers, crickets, armyworms, spiders, beetles	Fiji	Veitch, 1919
annularis L.	*Calpodes ethlius*	Trinidad	Mayer, 1935
annularis L.	*Calpodes ethlius*	Trinidad	Jackson, 1932
annularis L.	*Alabama argillacea*	Trinidad	Ballou, 1934
annularis L.	*Alabama argillacea*	Barbados	Report, 1918
annularis L.	*Laphygma frugiperda*	West Indies	Hinds, 1915
annularis L.	*Alabama argillacea*	St. Vincent	Jackson, 1927, 1928
hebraeus F.	*Pyroderces rileyi*	Hawaii	Ballou, 1928
hebraeus F.	*Chilo simplex*	Hawaii	Zwaluwenburg, 1928
hebraeus F.	*Levuana iridescens*	Fiji	Knowles, 1918
hebraeus F.	*Othreis fullonica*	Fiji	Jepson, 1917
hebraeus F.	*Schoenobius incertellus*	Far East	Shiraki, 1917
hebraeus F.	*Earias fabia*	Fiji	Anson, 1927
pallipes L.	*Fenusa pumila*	Connecticut	Friend, 1933
pallipes L.	*Crioceris asparagi*	U.S.A.	Chittenden, 1918
pallipes L.	*Pieris rapae*	U.S.A.	Chittenden, 1926
pallipes L.	*Pieris rapae*	Ontario	Twinn, 1924
gallicus L.	*Heliothis peltigera*	France	Fagniez, 1934
gallicus L.	*Leptinotarsa decemlineata*	Spain	Alfaro, 1945
gallicus L.	*Earias insulana*	Egypt	Willcocks, 1937

POLISTES SPECIES	HOST	LOCALITIES	REFERENCES
gallicus L.	*Prodenia litura*	Egypt	Willcocks, 1937
gallicus L.	*Laphygma exigua*	Egypt	Willcocks, 1937
gallicus L.	*Prodenia litura*	Egypt	Bishara, 1934
rubiginosus Lep.	*Laphygma exigua*	Florida	Wilson, 1933
rubiginosus Lep.	*Tmolus echion*	Trinidad	Harris, 1927
schach F.	*Chortoicetes terminifera*	Queensland	Veitch, 1935
aurifer Sauss.	*Pyroderces rileyi*	Hawaii	Ballou, 1928
americanus	*Anomis erosa*	U.S.A.	Dozier, 1917
bellicosus Cress	*Laphygma frugiperda*	U.S.A.	Hinds, 1915
bellicosus Cress	*Heliothes virescens*	U.S.A.	Morgan, 1923
crinitus Felton	*Alabama argillacea*	West Indies	Report, 1917
crinitus Felton	*Prenes nero*	Porto Rico	Jones, 1922
metricus Say	*Pieris rapae*	U.S.A.	Chittenden, 1926
cavapyta Sauss.	*Icerya brasiliensis*	Paraguay	Bertoni, 1924
major	*Terastia meticulosalis*	Porto Rico	Report, 1940
spec.	*Adoxophyes privatana*	Japan	Nawa, 1935
spec.	*Malacosoma neustria*	Japan	Hayaski, 1933
spec.	*Eriocampa mitsukurii*	Japan	Takenouchi, 1919
spec.	*Cirphis unipunctata*	Hawaii	Pemberton, 1923
spec.	*Erinnyis ello*	Brazil	Hynes, 1942
spec.	*Chloridea obsoleta* F.	Queensland	Currie, 1928
spec.	*Laphygma frugiperda*	Trinidad	Hynes, 1942
spec.	*Chloridea obsoleta* F.	Trinidad	Hynes, 1942

On the other hand, however, some few charges have been levelled against these wasps. De Stefani (1914) states that *P. gallica* L. is occasionally injurious to the vine in Palermo. *P. hebraeus* F. is considered as a natural enemy of silk worm in Japan (Nishikawa, 1919). Moreover, *Polistes* wasps have been involved in transmitting some agricultural pests. The mite *Oligonychus simplex* Banks, which is a serious pest of date palm trees, is probably aided in its spread by the wasp *P. hebraeus* F., which frequents the diseased clusters of dates attacked by the mite (Buxton, 1920). Wille (1935) stated that *P. canadensis* L. and *P. infuscatus* Lep., had been observed to distribute the first stage nymphs of the cottony-cushion scale, *Icerya purchasi* Mask.

P. gallicus L. and *P. fœderata* Kohl., build their nests occasionally in the vicinity of apiaries and in neglected mud hives, and it has been used to be thought that these wasps are capable of attacking bees. Close observations, however, have shown that these wasps never do any harm to bees whether they are on the wing or in their hives. But wasps may feed on honey if it is exposed as when extracting.

III. METHODS

A proper understanding of *Polistes* biology, particularly the nature of worker-queen relationship, entails examining the nests and their contents

in all stages of development. Several observations were made on nests of various sizes during the active brood-rearing season. Nests and their adult inhabitants were collected very early in the morning before or just after sunrise. The chill of the morning and the relatively higher humidity which prevail at that time of the day render wasps somewhat less active than at any other time of the day. They hold firmly to the distal surface of the comb which is normally directed downwards. An open wide jar was applied carefully to the hanging comb, and when the nest and its inhabitants were secured inside the jar the pedicel could be severed by a scalpel or a similar instrument. On several occasions the scalpel was hardly needed as nests were dropped when their sides were touched twice in opposite directions by the inner surface of the jar. The container was then covered and wasps were anaesthetised for sorting out and dissecting purposes. If in capturing a nest a number of wasps is lost they were found very often to form a swarm on the old nest-site. A visit to the spot next morning will often enable the observer to collect all wasps that were lost on the first trial. In several cases the swarm was found to build another nest on the same spot and eggs were laid in when a queen or an intermediate was present among the swarm.

During winter insects were caught on the wing and the captures analysed. A look for newly built nests was kept and they were searched for in places frequented by wasps in the previous breeding season. The growth of colonies was followed out by putting populous and newly built nests under close observation. These nests were founded in the spring of 1951 in a small neglected room in my house, and they were fixed to the ceiling which was 7 feet high. There were several outlets in that room, the door and the window were left open and there were several big holes in the ceiling. Observations were made early in the mornings at which time insects were almost motionless, so that adults and cells containing pupae could be counted and wasps marked. A cellulose-paint was used and insects were marked either on the thorax or the abdominal tergites.

Dissections were carried out in a saline solution composed of: NaCl, 7.5 g.; $NaHCO_3$, 0.1 g.; KCl, 0.2 g.; $CaCl_2$, 0.2 g.; H_2O, 1000 cc.

This was found to keep spermatozoa alive and show their active movement in the spermathecae. The latter organs were examined microscopically in a drop of the solution for the presence or absence of sperm.

IV. TERMS USED IN WASP-BIOLOGY

The terms used for describing the different aspects of wasp-biology are those outlined by Richards *et al* (1951) in their comprehensive account on the social wasps of South America; the terms pertaining to our species will be given here. In a *Polistes* colony there is either one egg-laying fer-

tilized female, *haplometrosis*, monogynous (Wheeler, 1923), or severals of such female, *pleometrosis*, polygynous (Wheeler, 1923). A colony is originally founded by a single fertilized female, *non-swarming*; or it may be founded by a group of insects of which at least one is a fertilized female, *swarming*. The latter case was not encountered in *Polistes* during the present work. It may happen, however, that a colony may be started by one fertilized female which is afterwards joined by others, *association*.

With regard to nest architecture *Polistes* wasps build generally a nest of one comb which hangs horizontally from a support by one or more pillars, a *stelocyttarous* nest. The comb is generally built in a sheltered place and no envelope surrounds it, a *gymnodomous* nest. The *petiole*, or *pedicel* (Rau, 1942) is the stalk or pillar which supports the comb to the ceiling or eaves or similar structures. The petiole is always in the centre of the back of the comb, and when the colony grows and the nest increases in size the petiole is reinforced with resinous substances. The nest is originally built of masticated wood cemented with saliva and propolis. Several additional petioles may be built on the periphery of the comb to support the original one, and this was found to occur only when the nest increases considerably in width. The cells open on the *distal* surface of the comb, which is normally directed downwards. The fused bottoms of the cells which form the back of the comb is termed by Richards the *proximal* surface of the comb. It is slightly sloping from the centre towards the periphery.

The shape of nests is generally round, the diameter may reach up to 5½ inches, but they may have a different shape if they are constructed in narrow spaces such as the empty trunks of bamboo trees where they generally have an elongated form. The width of the cells at their distal ends approximate that of the worker honey-bee, the cells measure 5 and 6 to the lineal inch in *P. gallicus* and *P. fœderata* respectively. The *length* of the cells which accomodate fully grown larvae was found to be 7/8 of an inch. This was measured from the bottom of the cell to the rim of the opening without including any additional elongation of the walls which is often formed by the spun silk of the pupating larvae.

The females in a *Polistes* colony fall under four different categories : *queens, auxiliaries, intermediates*, and sterile *workers*. All individuals in whose receptaculum sperm were found and their ovaries developed were called *queens*. A developed ovary is that which contains ripe eggs ready to be laid. The *ovarial score* is the number of developed eggs in the ovaries of a queen. Individuals in whose receptaculum sperm were found but their ovaries were not developed were termed *auxiliaries*. On several occasions auxiliaries with ovaries containing eggs of different developmental stages were encountered but because ripe eggs were not found they were not considered as queens.

The term *intermediate* is used for individuals in which sperm were absent but have more or less developed ovaries. The sterile *workers* are unfertilized females and have undeveloped ovaries.

All the above mentioned females have no morphological differences, and do not even show any difference in size. This is also the position in some other species of *Polistes* and *Mischocyttarus* (Richards, 1945; Rau, 1946, and Cumber, 1951). Difference in size may be rather attributed to the amount of fats stored in the body cavity, or, as will be mentioned later, to the number and stage of the strepsipterous parasites inside the abdomen.

In *P. gallicus* and *P. fœderata* males and females can easily be dist-

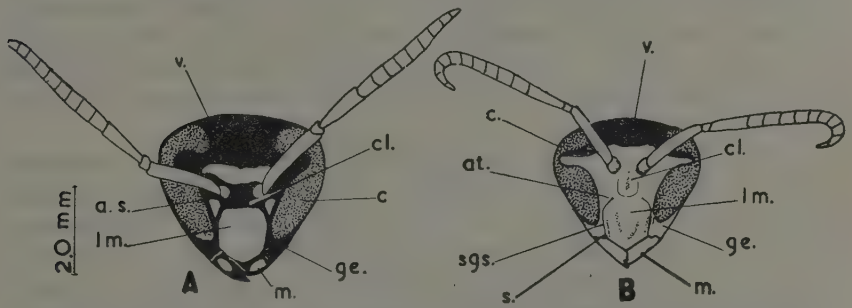

Fig. 1 : Facial view of the head of *Polistes foederata* Kohl, (A) female, (B) male. (*a.s.*, antennary sockets; *at.*, anterior tentorial pit; *c*, compound eye; *cl.*, clypeus; *ge.*, gena; *lm.*, labrum; *m*,. madible; *s.*, secondary anterior articulation of mandible; *sgs.*, subgenal suture; *v.*, vertex).

inguished from a distance. In both sexes the vertex is coloured black; but the area between the antennary sockets and which extends between the compound eyes including the clypeus and the labrum is coloured yellow in the male. In some males, however, there may be found a very small black spot inbetween the antennary sockets. In females there is a black area extending between the compound eyes and including the clypeus which lies inbetween the antennary sockets (Fig. 1). In some females there may appear one or two yellow spots in the clypeus. The antenna in the male is composed of 13 joints and the terminal ones are hook-like in form. In the female the antenna is 12-jointed and the terminal joints are not hook-like in form.

V. FACTORS DETERMINING BUILDING UP NEW COLONIES

1. General

At the outset of the active season the building up of a *Polistes* colony begins with a queen or an association of several queens which commence laying their eggs in either a newly built nest or in one which was used in a previous year. Generally nests are built of vegetable materials, worked

up into a sort of paper or carton. This is consisted of masticated wood pulp cemented together with saliva and resin. Adults were very often seen biting out bits of weather beaten wood from posts and fallen branches of trees. The nest always hangs horizontally from a central pedicel which is always darker in colour and well reinforced with resinous substances. Nests are always found in doorways, under eaves or suspended from ceilings of neglected rooms, barns or stables. Some are attached to posts and fences or found in sheltered positions on the outside of buildings. In winter or early in spring queens sometimes build their nests and attempt to hang them horizontally on a vertical and exposed wall which faces the sun during most of the day. When this is done, the nest seldom attains its full size and in most cases is abandoned early in its development. But when the nest attains its full size reaching 5 inches in diameter and containing about 750 cells or more, additional petioles may be built along the periphery in order to reinforce the comb to its support.

The factors which determine nest building activities are undoubtedly varied and intricate. Being an instinctive action, nest building is certainly inherited and is evoked by a complex of physiological and environmental conditions. To analyse these conditions is not an easy task as this sort of study of animal behaviour does not lend itself readily to laboratory work; it was deemed necessary, therefore, to study the insect in its ecological niche and to become acquainted with its mode of life.

2. Physiological condition of hibernating queens

In temperate regions it is a common belief that *Polistes* wasps gather in clusters in hollow logs and similar shelters in winter (R a u, 1940). Under such hibernating conditions all sorts of activities: searching for food, brood-rearing and nest building activities are suspended. So there is an intervening

TABLE I

Data of nest collected during winter for Polistes gallicus *L.*

NEST NUMBER	DATE NEST TAKEN	DIAMETER IN INCHES	NUMBER OF CELLS IN NEST	NUMBER OF QUEENS	OVARIAL SCORE	EGGS	LARVAE	PUPAE
A	20.XII.1950	2/5	3	1	5	present	none	none
U	31.XII.1950	3/4	16	3	4, 3, 2	present	none	none
CC	12. I.1952	3/4	18	1	4	present	present	present

hibernating period between leaving the old nests and founding the new ones. In subtropical regions and of course in the tropics the behaviour is different as there is no hibernation in the true sense of the word.

In Shebin El-Kom newly built nests in which eggs were laid were found in autumn and also in the most cold months of the year, namely December and January. Table I provides nest and brood data.

TABLE II

Data for Polistes gallicus *L. caught during winter*

NUMBER OF INSECTS COLLECTED	DATE OF COLLECTING	QUEENS	AUXILIARIES	INTERMEDIATES	WORKERS	MALES
11	27. XI.1950	0	10	0	0	1
2	17.XII.1950	2	0	0	0	0
2	21.XII.1950	1	1(*a*)	0	0	0
13	14. I.1951	4	8(*b*)	0	1(*c*)	0
23	14. I.1952	5	15(*d*)	0	3(*c*)	0
15	18. I.1951	10	5(*a*)	0	0	0
11	20. I.1952	5	4(*a*)	0	2(*c*)	0
3	22. I.1951	1	2(*a*)	0	0	0
9	23. I.1952	3	5(*e*)	0	1(*c*)	0
17	17. II.1951	14	3	0	0	0
8	26. II.1951	6	1	0	1(*c*)	0
114		51	54	0	8	1

(*a*) Ovaries contain eggs but not of the fully grown size.
(*b*) Of these eight auxiliaries five bad ovaries containing eggs of different immature stages.
(*c*) Workers were parasitized.
(*d*) Of these auxiliaries ten had ovaries containing immature eggs.
(*e*) Of these auxiliaries three had ovaries containing immature eggs.

TABLE III

Data for Polistes foederata *Koch caught during winter*

NUMBER OF INSECTS COLLECTED	DATE OF COLLECTING	QUEENS	AUXILIARIES	INTERMEDIATES	WORKERS	MALES
5	25.XII.1950	2	3(*a*)	0	0	0
4	14. I.1952	1	3	0	0	0
9	19. I.1952	0	9	0	0	0
12	29. I.1952	4	8(*b*)	0	0	0
2	30. I.1952	1	1(*a*)	0	0	0
32		8	24	0	0	0

(*a*) Ovaries contain eggs but not of the fully grown size.
(*b*) Of these auxiliaries three had ovaries containing immature eggs.

It is evident, therefore, that brood-rearing activities can take place in our region at any time in winter without the queens undergoing a hibernating stage during which they get sexually mature and their ovaries ripen. The ripening of ovaries of insects found in cracks and crevices in barns and neglected places and of those caught on the wing during the coldest months of the year was also ascertained. Tables II and III provide the results.

From these observations several conclusions can be drawn: (1) 40.7% of the total number of insects caught during winter were typical queens, being copulated and having mature ovaries. The ovarial score was found to range between 1 and 6 as shown in Table IV; (2) most of the auxiliaries had ovaries containing eggs of different immature stages, and so they were

TABLE IV

The ovarial scores of queens caught during winter,
(Data collected from queens shown in Tables I, II, and III)

OVARIAL SCORES.....	1	2	3	4	5	6	TOTAL
NUMBER OF QUEENS...	10	14	13	17	4	6	64

considered as females undergoing a transitional stage towards being queens; (3) no intermediates were encountered, and workers were extremely rare. They maintained their sterility because of parasitism, as will be mentioned later; (4) during winter males were totally absent or extremely rare, only one male was caught on the wing and that was at the end of November. In *Polistes* as well as among many other social wasps, as is well known, males perish during winter and reappear during the breeding season.

There was also another striking difference with regard to the amount of stored fat in hibernating queens and in those performing their reproductive function during the brood-rearing season. In females the fat content shows a fairly rapid rise towards the end of the breeding season. This high level of fat storage is maintained in winter up to the time when oviposition commences. The quantity of fat in the body cavity falls as oviposition proceeds and in the middle of the egg-laying season queens' bodies will contain highly developed ovaries and very reduced fat bodies. Most of the stored fat, therefore, goes in egg production and some is exhausted because of the greater rate of metabolism during the active season.

It is safe to deduce, therefore, that building up a new colony of *Polistes* is carried out by typical queens which are fertilized females and having developed ovaries. These females have been fertilized at the end of the active brood-rearing season which comes to a close towards the end of autumn.

During, or rather, at the end of the active season males are present in considerable numbers and they fertilize all females which have emerged during the same season. Stylopized females, however, are left unfertilized, typical workers, they can maintain their flying activities during winter but they were not observed to have a part to play in building up new colonies.

3. The presence of intermediates and auxiliaries

Intermediates occur among colonies under conditions still unknown, and although they are unfertilized females, yet they have mature ovaries containing fully ripe eggs. Their role in maintaining their colonies and ability of building up new nests is shown by the following experiment

On September 12th, 1950, a nest of *P. gallicus* of a moderate size (number B, Table V), was taken at 10 o'clock in the morning and brought into the laboratory. At this time of the day not all the adult inhabitants of a nest will be present on it. In the evening of the same day five adults were

TABLE V

Adult and brood data for nest number B

(Polistes gallicus *L.*)

DATE OF COLLECTING	QUEENS	AUXILIARIES	INTERMEDIATES	WORKERS	MALES	EGGS	LARVAE	PUPAE
12.IX.1950	1	2	0	11	7	present	present	14 (9 workers and 5 males)

found to gather on the same spot where the nest was. These wasps certainly belong to the same colony ; they were left, watched daily and their activities recorded. The analysis of capture of the original nest is shown in Table V.

Early on the next day the five insects which were left where the original nest was, were inspected and found to be all females. They were all marked on the thorax and the abdominal tergites. At 11 a.m., on the same day the insects were engaged in building up a new nest, the pedicel and two cells were already formed and each cell contained an egg. The eggs were deposited while the cells were quite shallow and incomplete. While watching a third cell was constructed , a female brought a dark pellet between her mandibles which together with her front pair of legs were used in transforming that pellet into thin carton. The bottom of the cell was formed and the walls were slightly raised in a few minutes during which time the insect was moving actively on the edge of the cell ; her body was arched and the antennae

were directed downwards and moving rapidly. When this was over the insect stood for a while cleaning her mouth parts, antennae and legs, and flew away. Another female approached the newly built cell which was now less than 2 mm. long and laid an egg. The egg is usually attached to the corner of the hexagon by a short stalk from the hinder end.

The raising of the other cells was also carried out in the same way; the next day a 4th cell was constructed, and an egg laid. The sequence of events in constructing the cells can be summarized, therefore, in the following: (1) the bottom of the cells are constructed and the walls are slightly raised; (2) eggs are laid, and each cell contains only one egg; (3) the walls of the cells are continuously raised to accommodate the growing larvae.

It was found that all of the five females took a part in constructing the cells, but as far as egg-laying is concerned I was unable to find out if all females had deposited.

TABLE VI

Nest data for Polistes gallicus *L. collected during October 1950*

NEST NUMBER	DATE OF COLLECTING	DIAMETER IN INCHES	QUEENS	AUXILIARIES	INTERMEDIATES	WORKERS	MALES	EGGS	LARVAE	PUPAE
H	8.X.1950	2	1(*a*)	0	0	9	11	present	present	18
K	9.X.1950	1½	1	10	0	0	0	none	none	27
L	13.X.1950	1½	0	8	0	1	0	»	none	none
M	13.X.1950	2	0	6	0	1	4	»	present	3
N	13.X.1950	1½	0	4	0	0	0	»	none	none
O	13.X.1950	1	0	5	0	1	0	»	present	none
P	14.X.1950	2	2(*a*)	2	0	9	38	»	none	3
Q	14.X.1950	1	0	0	0	3	10	»	none	none
T	28.X.1950	2	0	0	0	10	13	»	present	18

(*a*) Ovarioles degenerating, no egg-rudiments, but the presence of *corpora lutea* shows that these females were queens.

On September 18th, that was six days after the removal of the original nest, the newly built one was found to be composed of 11 cells of nearly the normal length, each containing an egg, and a few incomplete empty ones. The nest was then taken with its inhabitants and all females were dissected. It was found that two of them were typical workers, but the other three were intermediates; the ovarial score was 6 in every female.

Thus it appears that although signs of division of labour could not be ascertained in a *Polistes* colony, yet there is enough evidence to show that intermediates as well as workers participate in building up their nest. In

addition, intermediates can maintain their colony, but they will give rise only to male offspring.

In the middle of the active season auxiliaries are generally rare. But they increase in number towards the end of the season as they are the fertilized females which will be the queens of next year. Table VI shows the analysis of capture of nest collected during October 1950.

It is clear that in 6 out of 9 nests collected in October auxiliaries were present in varying numbers ranging between 2 and 10. In these fertilized females ovarioles will develop after a varying length of time and when they become queens they can start building up new colonies when conditions are well suited. It is also clear that most of the colonies have no queens and so eggs were absent in nearly all of them. This indicates that at this time of the year the reproductive season in these colonies was coming to an end.

4. Environmental conditions

The size which the colony may reach during the season depends on several factors. Among them is the success of the foundresses in building up new colonies in the early period of the season. This is attributable to several environmental conditions, such as cold or warmth, wetness or dryness and the amounts of sunshine or gloom. Moreover, the abundance of nectar-bearing flowers, as well as the abundance of caterpillars influence to a certain extent the progress of a colony. Furthermore, the size of the nest is influenced to a great extent by whether it was a *non-swarming* or a co-operative start, *association*.

The progress of colonies was followed out by putting two nests, founded early in the season of 1951, under close observation from the time they were first built. These observations show the effect of different environmental conditions on nest building activity and also the detail of this behaviour. The first nest (no. DD) was first observed on February 15th, and it was built in a small hole in a wall facing south and the place was protected by another wall situated to the east. On sunny days the place was, therefore, pretty warm as temperature rose to 31.5° C. close to the nest. However, the choice of this place by the foundress for the construction of her nest was not a success, because the narrow space of the hole hindered the progress of construction; so the nest was abandoned on March 28th, and observation ended. The second nest (no. EE) was first observed on March 1st, when it contained 2 cells; it was fixed to the ceiling of the neglected room referred to on page 375. Observation was carried out till May 27th, when nest was abandoned; it contained then 24 cells, 7 of which were spun over.

In the two cases the behaviour of nest construction was essentially the same, except that the building up of the first nest was started by one queen

which was joined by another after the elapse of 15 days; the second nest, however, started by the association of two queens, one of them was found to be marked. She had been a member of another colony lived in the same room and was dispersed at the end of September 1950. The effects of the

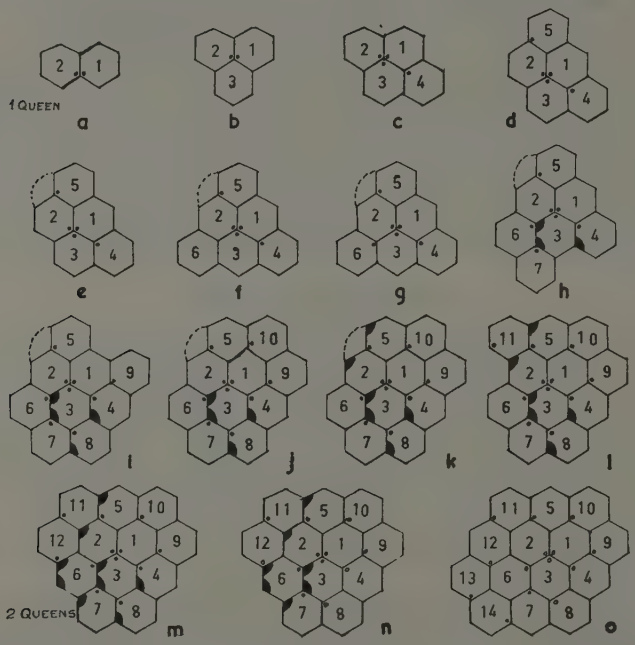

Fig. 2: The growth of a colony of *Polistes gallicus* L. during the first month of its life (Nest DD).

(*a*., 15.ii.1951, 3 p.m., 26° C., 2 cells, each contained an egg; *b*., 16.ii., 10.30 a.m., 15° C., cell 3 built; *c*., 16.ii., 12.45 p.m., 26.5° C., cell 4 built, an egg was laid in 3 and 4; *d*., 17.ii., 3 p.m., 26.5° C., cell 5 built + egg; 18.ii., 2.30 p.m., 15.5° C., raining, queen motionless, no progress; 19.ii., 8 a.m., 12° C., no change; *e*., 20.ii., 12 noon, 18° C., little advance in a cell close to number 5; *f*., 21.ii., 1 p.m., 25° C., cell 6 built; *g*., 22.ii., 2 p.m., 26° C., cell 6 raised + egg; *h*., 23.ii., 10 a.m., 13° C., cell 7 built + egg, 2 honey drops in 3, 1 in 4; *i*., 23.ii., 2.30 p.m., 28° C., cells 8 and 9 built + eggs; 4.10 p.m., 31° C., no change; 5.30 p.m., a honey drop in 8; *j*., 24.ii., 2.45 p.m., 28° C., cell 10 built + egg; *k*., 25.ii., 9 a.m., 16° C., no change; 2.45 p.m., 23° C., a honey drop in 5; 26.ii., 4 p.m., 26.5° C., no change; 27.ii., 12 noon, a honey drop in 2, no change; *l*., 28.ii., 8 a.m., 16° C., cell 11 built + egg; *m*., 1.iii., 3 p.m., 31.5° C., cell 12 built + egg, 2 honey drops in 6, 1 in 7; 2.iii., 2.45 p.m., 31° C., a second queen observed, marked; *n*., 3.iii., 4.30 p.m., 21° C., weather dull, honey drop in 8 becoming smaller; 4.iii., 8.15 a.m., 16° C., no change; 5.iii., 3.15 p.m., 27° C., honey in 4 and 8 consumed, larva in 1 growing; 6-8.iii., no progress; 8-10.iii., observations were unavoidably interrupted; *o*., 11.iii., 3.45 p.m., 19.5° C., dull, no progress, all eggs hatched, honey drops disappeared; 12-16.iii., no progress, queens are always on nest; 17.iii., 3.45 p.m., 30° C., cells 13 and 14 built + eggs, all other eggs hatched).

different environmental factors on the activities of both the queens of nest DD and EE were identical, and so a summary of the observation together with a diagram representing the different stages in nest construction is given for one nest only (DD, Fig. 2).

As was mentioned before the low temperature of the early mornings together with the relatively higher humidity rendered the queens motionless on their nests. As temperature rises they start moving, but they never go on foraging or collecting constructive material unless it is sunny and warm, temperature being above 20° C. Building activities are also suspended if temperature falls beyond that degree or if it is raining or dull (Fig. 2, stages *d* and *o*). But the rate of cell construction gets certainly higher with the rise of temperature and with the increase of the amounts of sunshine. When the queen is devoting all her time to nest building activities the rate of construction gets also higher than when eggs hatch and larvae have to be fed. This is clearly shown when the number of cells which were built between February 15th and 28th, and those built between March 1st and 11th were considered. During the first period, which was 13 or 14 days long, 11 cells were built and there was only one queen, but during the second period, which was 11 days long, only 3 cells were built although there were two queens and conditions were more favourable.

Like many other species of *Polistes*, *P. gallicus* and *P. fœderata* deposit small drops of honey in the cells containing eggs. Storing honey is of a common occurrence in nests at the beginning of the season. It is stored in the form of brownish transparent drops fixed to the corners of the cells near their distal ends. The drops, sometimes, dry up and appear as brownish hard masses. In the above mentioned nest the queen started to store honey after 8 or 9 days from her start of building up the nest (Fig. 2, stage *h*). Then there came an increase in the number of honey drops till March 1st, when there were 9 drops stored in 7 cells; those stored in cells 2, 3 and 4 were now dry and hard. Since then the drops began to decrease in number, those which were in cells 4 and 8 were consumed on March 5th; this was found to coincide with the growth of the larva in cell 1 (Fig. 2, stage *n*). Moreover, all honey drops were found to disappear on March 11th, at which time all eggs were found to have hatched and larvae grown. It may well be presumed that honey has been used in feeding the young larvae.

This sort of work on the part of queens at the outset of building up their colonies certainly hinders the progress of nest construction. But when workers emerge and increase in number nest building will proceed more quickly, depending of course on the different climatic conditions.

There is also another sort of behaviour which takes a part in accelerating the process of building up a new colony. Most nests are annual developments

but several nests which have been abandoned during winter were found to be used again by queens at the beginning of the active season. In the bottom of the cells of such nests there accumulated the excrement and the old skin of the previous larvae; and the silk which was spun by them, lining the walls of the cells and extending over their distal ends could be observed. Such a behaviour enables the queens to devote all their activities to brood-rearing and so the progres of such colonies will be rapid.

VI. THE GROWTH OF A COLONY

1. Egg-laying of associate queens

Other than the different environmental conditions the number of queens which start in an association to build up a new colony certainly determines the size a colony will attain during the active season. Although there is no sufficient quantitative evidence on the point it seems that all queens participating in building up a new nest lay their eggs at a normal rate. But it has been pointed out that in *P. gallica*, though several queens may co-operate in founding a new colony, yet there is always only one female that becomes the functioning queen, and that the egg-laying and ovarial develop-

TABLE VII

Nest data for Polistes gallicus *L. collected at the beginning of the active season*

NEST NUMBER(*a*)	DATE OF COLLECTING	NUMBER OF CELLS	EGGS	LARVAE	PUPAE	QUEENS	OVARIAL SCORE
V	4.III.1951	95	80	present	none	5	2, 3, 2, 3, 5
EE	23.III.1951	25	15	»	3	2	4, 5
FF	23.III.1951	18	10	»	3	1	3
GG	23.III.1951	20	9	»	none	1	4
HH	23.III.1951	20	11	»	none	1	5
II	23.III.1951	26	14	»	3	2	3, 6
W	5.IV.1951	34	16	»	12	2	3, 5

(*a*) All nests were newly built except number V which was of the previous year.

ment of the others are suppressed (Richards *et al*, 1951). Richards explains this by stating that « probably the queen is the one whose ovaries happen at the start to be best developed and she so dominates and terrorises the others that they gradually cease egg-laying ». This implies that there will be a great difference in the size of the ovaries in these two types of

queens owing to the energy the dominated ones may expend on foraging and constructing, and the excess nourishment the dominant female may receive as well as the less efforts she will undertake. This was not substantiated during the present work; ovaries of all associate queens were found to be equally developed and ovarioles to contain many of the conspicuous yellowish-green empty follicles of the ovulated eggs, *corpora lutea*; an indication that all associate queens laid their eggs (Table VII, and Fig. 3).

It is clear from Table VII that the number of eggs is proportional to the number of queens found on nests. If the domination theory were right there would not have been such a great variation in the number of eggs

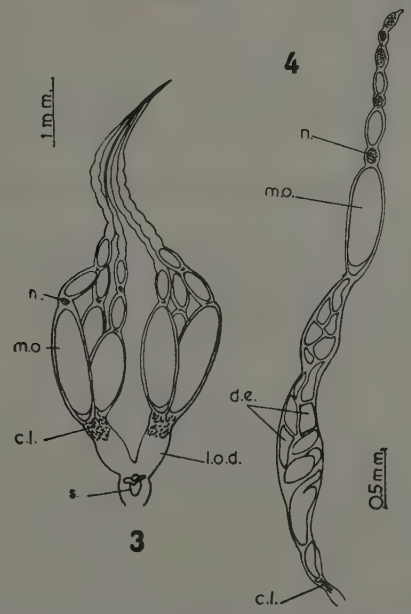

Fig. 3: Reproductive organs of a female of *Polistes gallicus* L. (*c.l.*, corpora lutea; *l.o.d.*, lateral oviduct; *m.o.*, mature ovum, *n.*, nurse cells; *c.*, spermatheca).

Fig. 4: The suppression of egg-laying in a queen, an ovariole showing the disintegration of eggs (*c.l.*, corpora lutea; *d.e.*, disintegrated eggs; *m.o.*, mature ovum; *n.*, nurse cells).

found in the above nests. As is shown in the Table, these nests were not built at the same time and so we have more than one variable; but in such a work the study of egg-laying behaviour and the comparison of the total egg output of different queens building their nests at the same time and under the same conditions is a far reached achievement. And as the method of marking will not solve such a problem one has to accept such data *per se*.

Moreover, the structural modification and the arrangement of eggs in the ovarioles of queens kept in captivity for a varying length of time away from their nests, which are the only egg-laying sites, will contradict the domination theory. The suppression of egg-laying in queens at the outset of the active season was found to bring about some changes in the ovarioles which were not encountered in either the queens which were working in an association to build up a new colony, or those caught on the wing during this particular period of the season.

Nests were collected and queens were isolated in a separate cage where they were fed on honey or sugar solution. After 12 days queens were dissected and ovarioles examined. They showed at their proximal ends the accumulation of different numbers of eggs which varied in shape and size; and in a typical case ripe as well as other immature eggs were found at the distal end of the ovarioles (Fig. 4). This congestion of disintegrated eggs is a result of suppressing egg-laying in those queens.

2. The change in the size of a colony

As has been previously mentioned colonies are founded by queens at any time during winter or early in spring. If environmental conditions were favourable and nests were not attacked by their most serious enemies, viz., ants and birds, colonies may attain a very big size. The most populous nest found during this work was a nest of *P. fœderata* collected on October 1st, 1950. It was 5½ inches in diameter and was constructed in an empty mud hive, it contained 504 adult insects: 359 were females and 145 males, 7 pupae, 6 larvae and no eggs. 298 females were dissected and they were found to be all workers. The whole population was heavily parasitized as stylops' larvae were frequently met with during dissecation; a fact which shows that stylopization does not hinder the progress of a colony.

The study of the gradual changes in the size of a colony and the dispersion of its adult inhabitants were followed out in a populous nest of *P. gallicus* throughout 1950-1951 season. The nest was first observed when at its incipient stage at the beginning of March, but brood cells and adults were not counted until May 12th. During June and July observations were carried out every 10 days; in August the study was unavoidably interrupted, but from the beginning of September 1950 till February 16th 1951, when all the population had dispersed, daily observations were carried out. Of the brood cells only those covered by cocoon caps were counted; and although observations were made early in the mornings there had been several fluctuations in the number of adults because of the difficulty of counting them as they were continuously moving; and also because of their concealment on cold mornings in the space between the ceiling of the room to which

the nest was supported and the proximal surface of the comb. In the end the nest was oblong in shape 5 × 4 in., and contained 491 cells. The data are shown in Fig. 5.

It is clear that there was a gradual increase in the size of the population, and that the progress was slow at the beginning but during the first half of September it was relatively faster. If we presume that during summer months weather conditions would be more or less the same, so this difference

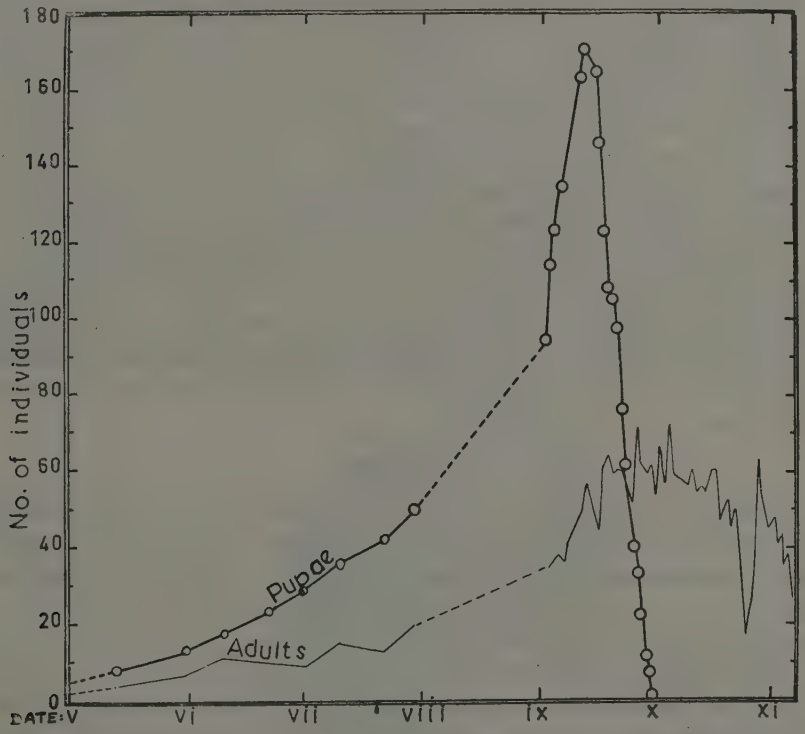

Fig. 5: The change in the size of a colony of *Polistes gallicus* L. throughout the season.

in the rate of growth would be attributed to the fact that the first larvae which were attended by the associate queens grew much more slowly than the later ones which were more adequately nourished by the increasing number of workers. The number of pupae reached its maximum (171) on September 12th, and from that date onwards the emergence of adults was very rapid; the maximum number of daily emergence was 23 on September 17th. On September 30th, all adults emerged. This period of rapid emergence was found to coincide with an increase in the number of adults. Theoretically

the number of adults ought to have approximated that of the pupae, especially when all adults emerged, but it can be observed that the number of adults never exceeded 72. This might be attributed either to the fact that wasps are short lived during this period or the probable occurrence of swarming. The longevity of queens and workers is a gap in the knowledge of wasp-biology and researches along this line will certainly reveal interesting informations especially when the method of marking is adopted.

Generally the dispersion of adults occurs gradually and is completed at the end of October; but in the above mentioned colony dispersion was completed on February 16th, and that perhaps was because the place was relatively protected. On December 20th, a new nest of 3 cells was founded by one of those over-wintering queens close to the original one. Nest and queen were taken for examination and data are shown in Table I, nest A. Probably this queen had the best developed ovaries at this particular period, and so she started nest building activities as conditions were favourable.

The number of cells in any nest is not identical with the number of individuals reared, as cells may be used more than once. Moreover, the shallow cells round the periphery of the above mentioned nest were found not to have been used as they contained neither cast skin nor excrement. There were also some marginal cells that contained dead first or second larval stages.

3. Development

From the foregoing account it can be observed that the rate of development of immature stages is dependent on so many factors: temperature, other environmental conditions and nourishment. Wheeler (1910) has shown that in *Polistes* the development of the larvae is retarded by stylopization.

Under natural conditions when nests are newly founded it is possible to find out the duration of the different immature stages as nests, at that stage, contain a few number of adults. But in the middle of the active season only the duration of the pupal stage can be ascertained by watching colonies and marking the tops of the cocoon caps when they are first formed. Nests which were known to have either newly laid eggs or newly formed cocoons were also brought into the room referred to above and fixed to the ceiling for the same purpose. In the laboratory, however, temperature in March and April when these observations were carried out was invariably lower than in the field, so data obtained from nests brought into the laboratory were not considered as they largely varied from those obtained under natural conditions.

The pointed hind end of the eggs are always embedded in the substance of the nests, and usually attached to the corners of the cells. The eggs are about 1.6 mm. in length, but there were some few queens which produced much smaller eggs, 0.9 mm. long. When they hatch they give rise to the first stage larvae which remain fixed to the corners of the cells. But as they grow in size their hind ends lose attachment to the corners of the cells and the bodies of the larvae assume somewhat a spindle shape. The body which comprises 3 thoracic and 10 abdominal segments is whitish, but the head is brown because of the appearance of the dark sclerotized epicranium, mandibles, labium, labrum and maxillae. There are from 5 to 7 larval instars and when the larva gets fully mature it spins a white silken cocoon which lines the walls of her cell and closes its distal end. The silk is secreted by a pair of salivary glands extending along the sides of the gut. Each gland consists of two long convoluted tubes which join each other in the third thoracic segment. The unpaired tubes of both glands extend and taper anteriorly and coalesce under the sub-oesophageal ganglion forming a short and narrow tube which opens to the outside on the tip of the labium (Fig. 6B). When silk is secreted the labium is very much protruded (Fig. 6A), and the two dark pointed processes on the sides of the salivary glands' opening help the larva in spinning her silken cocoon. The whole process could

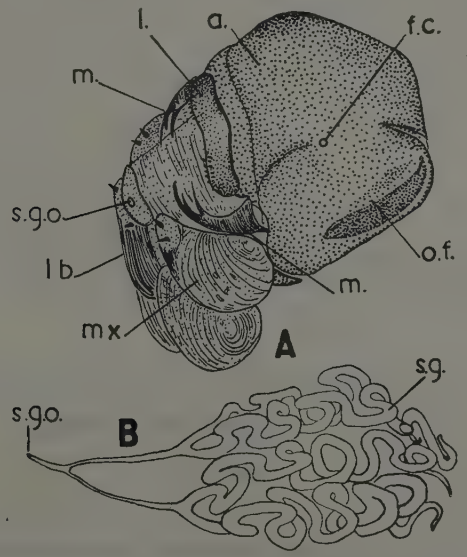

Fig. 6: (A), a side view of the head of a larva of *Polistes gallicus* L. during secreting the silken cocoon (*a.*, frons + clypeus; *f.c.*, antenna; *l.*, labrum; *lb.*, labium; *m.*, mandible; *mx.*, maxilla; *o.f.*, ocular fossa; *s.g.o.*, salivary glands opening); (B), the salivary glands (*s.g.*, salivary gland; *s.g.o.*, salivary glands opening).

be observed under a binocular microscope, and it was found that spinning a cocoon cap took about 30 minutes. The cocoon cap was found either attached to the distal margin of the cell or lies a little distance below the rim. Workers sometimes plaster very thin pieces of carton on the tops of the cocoon caps.

113 cocoons whose caps were attached to the distal margin of the cells were examined in order to find out the sex of their contained pupae. It was found by dissections that 61.9% of these pupae were females and 38.1% males. 89 cocoons whose caps were laying below the rim of their cells were also examined and it was found that 12.4% of the contained pupae were females and 87.6% males. A small nest containing 25 cocoons was brought into the laboratory and sex was determined when adults emerged. Of these cocoons 18 had their caps attached to the distal margin of their cells and 7 had the caps below the rims. From the former cocoons 12 workers and 6 males emerged but only males emerged from the latter. And although there seems to be a tendency for female pupae to have their cocoon caps attached to the distal margin of their cells, yet the evidence is not conclusive. I presume it is a matter of nourishment, as when nests were brought into the laboratory and nearly fully grown larvae were not fed further, they formed their cocoons and the caps were lying below the rim of their cells.

In March and April eggs may hatch in 8-11 days, larvae may take 40 days or perhaps more to get fully mature, and pupae (including the prepupal stage) 15 days depending upon weather conditions. So at the beginning of the active season it requires about 64 days from the deposition of the eggs to the emergence of the adults. In an observation carried out in the room referred to above an egg was deposited on March 4th, hatched on March 14th, the larva spun its cocoon on April 30th, and the adult — which was a male — emerged on May 15th. So in this case the adult emerged in 72 days from the time the egg was deposited. The developmental period may be very much curtailed during the season; eggs hatched in 7 days and the pupal stage took 9 days in July.

VII. THE BIOLOGY OF THE STREPSIPTERON XENOS VESPARUM ROSSI

1. General

In Egypt Nassonow (1893), according to Pierce, 1909, page 56, was the first author to record the occurrence of the strepsipterous parasites among wasps; he was able to detect the triungulinidis in a nest of *P. gallicus* in the middle of March. Strepsiptera has a world wide distribution and occurs among Orthoptera, Hemiptera-Homoptera, Hemiptera-Heteroptera and

Hymenoptera (Pierce, 1909). In the latter order the hosts are known to belong to twelve different families (Clausen, 1940).

Polistes wasps were found to be extensively parasitized by the strepsipteron *Xenos vesparum* Rossi, and stylopized wasps may be found at any time of the year. During development the larvae of the parasite, except the triungulinid, exhibit an endoparasitic mode of life which is retained throughout life in the female. The cephalothorax of the female and the anterior end of the male puparium protrude through the inter-segmental membrane of the abdominal segments of the wasp and are visible externally.

The writer wished to acknowledge the help of Prof. H. Priesner in identifying the strepsipterous parasite.

2. The appearance of the triungulinids

The eggs hatch within the body of the female and the triungulinids issue in large numbers through the brood canal which runs forward to open by a crescentic slit on the cephalothorax. The time of their first appearance was recorded by examining wasps at varying intervals throughout the year. In winter stylopized wasps can be found among the hibernating females which contain only the fully developed female *Xenos vesparum*. Male parasites, however, do not exist during winter as their emergence comes to an end towards the end of autumn. In 1950 the last male emerged from a lot of stylopized wasps kept in the laboratory on November 27th. The male is generally very short lived and its sole purpose is to fertilize the female parasite, which act is accomplished by ejecting the sperm in the brood canal of the female. In some cases, however, it appears probable that parthenogenesis occurs among these insects (Imms, 1934). However, *Xenos vesparum* overwinters in the form of fully developed female whose body cavity contains an enormous number of eggs. In 1951 the first stylopized wasp was encountered on January 14th. This was found to be a worker of *P. gallicus* containing a mature female parasite harbouring a large number of eggs. On February 26th, another stylopized female *gallicus* was encountered containing a fully developed female *Xenos*; triungulinids were observed coming out of the aperture of the brood canal. A similar stylopized worker was caught on 28th, February 1951, and a fourth on March 1st. No triungulinids emerged from the latter until March 4th, when they made their first appearance. The death of the host which occurred on March 17th, brought about the death of the parasite as well as the triungulinids.

In 1952 similar results were obtained. On January 14th, three stylopized wasps were caught. They were found to be workers of *P. gallicus* and each was harbouring a mature female parasite which contained no triungulinids but an enormous number of ripe eggs. On January 20th, two similar stylo-

pized workers of *P. gallicus* were found, and on January 23rd, another female *gallicus* harbouring two mature female parasites was caught. No triungulinids were observed and so the host was kept alive. On January 27th, the triungulinids made their first appearance and when the wasp was dissected it was found to be a worker and only one of the female parasites had the hatching larvae, the other contained only eggs. It is safe to conclude, therefore, that: (1) generally triungulinids make their first appearance in February, increase in number and distribution during March and attack the early larvae of *Polistes* at the beginning of its active brood-rearing season; (2) the parasite is transferred from one season to another in the form of fully mature female, and that probably the occurrence of parasitism that prevents the female workers from being insemīnated.

3. The development of the parasite

The triungulinids attach themselves to the body of the host until opportunity is afforded for spreading, and because of their very minute size their method of securing a new host has not been directly ascertained. But it is maintained by Salt (1927) that in the nest the triungulinids will find opportunity to enter a cell containing a host in the larval stage and to borrow into its body, leaving untouched the eggs and the pupae. This view may be accepted if the stylopized sterile worker which carries the enormous number of triungulinids was observed to take a part in nest building activities. But such a behaviour has not been recorded, and during the present work all females involved in building up new colonies were sound fecundated queens. During the season, however, it may be possible that such a way of securing a new host will take place. At the beginning of the active season the more likely method of reaching a new host is this. The triungulinids, presumably, leave the maternal host when it is on flowers, and they attach themselves to other queens which come to secure food from these particular flowers and thereby become transported to new colonies. Triungulinids may also secure new hosts by being liberated in places where new colonies are being founded.

The investigation of this particular part of the life-history of the parasite is of special importance to the problem of the effect of stylopization on the host, for on it depends the length of time through which the host is subjected to the influence of its parasite. If the triungulinids enter a very young larva, their presence is felt over a longer period and their effects are probably more marked than if they enter one almost mature. During the fall of 1950 season it was observed that colonies founded in a number of empty mud hives placed in the Faculty's farm were heavily parasitized. At the

beginning of 1951 season two new nests of *P. gallicus* built in the same place were collected and their contents examined.

Nest no. 1, was collected on April 5th, and had 31 cells : 13 containing pupae, 10 larvae of different stages, and 8 containing eggs. There were two foundresses, and the result of dissection was as follows :

(1) Foundresses : not parasitized ; (2) two workers emerged on April 9th : one was stylopized, containing an advanced female larva, but the other was not ; (3) one male emerged on April 14th : stylopized, containing an advanced female larva ; (4) one male emerged on April 16th : stylopized, containing an advanced male larva ; and (5) two workers found dead in their cocoons on May 3rd : stylopized, each containing an adult female *Xenos*. They were examined again on May 14th, and both female stylops found dead.

Nest no. 2, was collected on April 5th, and had 23 cells : 10 containing pupae, 8 larvae of different stages and 5 containing eggs. There was one foundress and the result of dissection was as follows :

(1) Foundress : not parasitized ; (2) one worker emerged on April 6th : stylopized, containing two advanced female larvae ; (3) one worker emerged on April 7th : stylopized, containing a young larva ; (4) a larva of the third instar, dissected on April 7th : stylopized, containing a second stage larva ; the cast skin of the triungulinid was observed in the host's body cavity ; (5) a larva of the second instar, dissected on April 7th : stylopized, containing 3 triungulinids ; (6) one worker emerged on April 8th : stylopized, containing four advanced female larvae, one advanced male larva and a young stage one ; (7) a larva of the second instar, dissected on April 8th : stylopized, containing a second stage larva, the cast skin of the triungulinid was observed in the host's body cavity ; and (8) three workers found dead in their cocoons on April 26th : stylopized, one containing a dead male puparium and each of the others a dead female *Xenos*.

There is another set of data collected from examining insects caught on the wing at the outset of and during the active season and the results show that there are more than one generation of *Xenos* during the year. The conclusions which can be drawn from these observations are that :

(1) All larval instars of the host are subjected to the attack of triungulinids (vide points : 3, 4, 5, 6, and 7, nest 2) ; (2) the death of the hosts while still in their pupal cocoons is due to their having been parasitized very early in their larval stages (vide : 5, nest 1 ; and 8, nest 2) ; (3) the death of the host brings about the death of the parasite even if the latter has reached maturity ; (4) assuming that the beginning of March marks the time when triungulinids attack their hosts *Xenos vesparum* requires about 60 days in order to penetrate the host's body (vide : 5, nest 1 ; and 8; nest 2). It is

known that whatever early the host larva may be attacked by triungulinids *Xenos* never reaches maturity while the host is still in its larval or pupal stage. Table VIII shows the time which elapsed between the emergence of the host and the appearance of the parasite. If a certain period is allowed for

TABLE VIII

Time elapsing between host's emergence and the appearance of parasites

HOST NUMBER	HOST	DATE OF EMERGENCE	TIME (IN DAYS) ELAPSED TILL PARASITE PENETRATED BODY	SEX OF STYLOPID	REMARKS
1	worker	24.IV.1951	16	male puparium	Adult male *Xenos* emerged one day after the appearance of the puparium; host died two days later.
2	worker	24.IV.1951	21	female	
3	worker	25.IV.1951	19	female	Host died twelve days later, no triungulinids appeared.
4	male	28.IV.1951	16	female	Host died two days later, no triungulinids appeared.

the emergence of males, fertilization and incubation period there will not be more than two generations during the host's active season. At the end of this period the triungulinids of the third generation will attack the larvae of those wasps which will go into hibernation and will reach maturity at the beginning of the next season. *Xenos*, therefore, will presumably have three generations a year.

VIII. THE EFFECT OF STYLOPIZATION

The internal and external effects of stylopization on the hosts have been studied in different forms of wasps and bees by many authors; and the whole subject is also discussed by Pierce (1909), Wheeler (1910) and Salt (1931). In *Polistes*, save that stylopized specimens of *P. crinitus* appear paler than healthy individuals, all authors agree that there are no modifications of morphological characters which can be attributed to the presence of parasites. This is what has been found during the present work, but the appearance of heavily parasitized wasps deserves further comment. Heavy parasitism was found to increase the size of the abdomen and to exert varying degrees of asymmetry on the host's abdominal segments. Heavy parasitism also inflicts serious consequences on the spread and maintenance of the species, as it curtails the life of the host and its death brings about the death of the parasites.

The asymmetry of the host's abdomen is clearly shown in Figure 7. This worker emerged on April 25th, 1951, from a nest of *P. foederata* brought into the laboratory on April 5th, and because the asymmetry was apparent she was marked and left alive. She died on April 28th, and when dissected she was found to contain 2 male pupae about to penetrate the inter-segmental

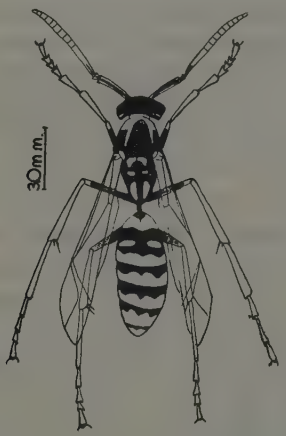

Fig. 7 : A stylopized worker of *Polistes foederata* Kohl, showing the asymmetry of the the abdomen.

membrane, one female larva, and another young one. The early parasitism which had taken place during the host's larval stage together with its repeated occurrence resulted in killing the adult wasp three days after emergence. In such a case the death of the contained parasites is inevitable.

The occurrence of several *Xenos* larvae in the body of the host has been pointed out by several workers, the highest number of which is 31 recorded by Brues (1905). The number of *Xenos* larvae which can reach « maturity » (1) in the body of individual wasps is shown in Table IX and Figure 8. These findings were observed in a group of 32 stylopized wasps collected between October 23rd, and December 26th, 1950. It appears that a host can supply nourishment to bring up to four parasites to their « mature » stage. In the literature there are records giving up to 15 male puparia in the body of a single male wasp of *P. annularis*. Also, in this group of stylopized wasps it was repeatedly shown that the death of the parasite was a usual concomitant of the host's death. This fact will bring about an important

(1) In this connexion « maturity » is not used in its strict meaning, but it means here the stage when the female cephalothorax or the male rounded tuberculated apex of the puparium penetrates the inter--segmental membrane.

point in stylops-biology in relation with the hibernating season of the host. In order to cross the gap between two successive seasons stylops must adjust the time of attacking their host larvae, as not to kill the adult wasps in the

TABLE IX

Number of « adult » Xenos occuring in the body of individual wasps

NUMBER OF HOSTS CONTAINING			
1 PARASITE	2 PARASITES	3 PARASITES	4 PARASITES
18: 7 males 11 workers	10: 7 males 3 workers	3: 2 males 1 worker	1 worker —

middle of the hibernating season ; a fine adjusted inter-action indeed. It may be stated that it is only those triungulinids which will attack the most advanced larvae, at the end of the active wasp-season, that will survive the winter without causing the death of their hosts.

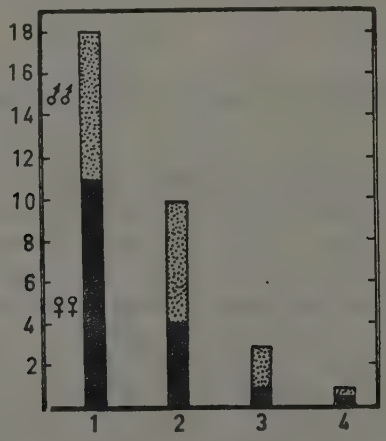

Fig. 8: Histogram showing the numbers of adult *Xenos* occuring in a group of 32 stylopized wasps collected between October 23rd and December 26th, 1950 (Table IX). Male and female *Xenos* are proportionally shown.
Abscissa : number of adult parasites per host. — Ordinate : number of hosts.

IX. DISCUSSION

Polistes colonies are always annualy development, and at the beginning of the active season or whenever conditions are favourable they are either built up by a single queen or an association of several queens. But factors which determine nest building activities are by no means fully understood.

A study of the physiological condition of hibernating insects revealed that they are almost always fertilized females containing either fully developed ovaries, typical queens, or ovaries which contain a number of immature eggs, auxiliaries. There is enough evidence that temperature fluctuations, which invariably occur during winter, exert considerable influence in accelerating ovarial development among the hibernating wasps. Deleurance (1948) has shown that when females of *P. bimaculatus* or *P. gallicus* were kept at 0° C. for 20 days it was possible to initiate partial development of ovaries when they were brought back to 25° C. But when they were subjected to 0° C. for a longer period, i.e., 40 days females were able to lay eggs when brought back to warmer conditions. Intermediates, « workers » and males are totally absent during winter. The quantity of fat stored in the body of hibernating queens is considerably high. During the active season it is rapidly consumed because of the active process of egg production and the greater rate of metabolism.

But nest building activities are not exclusively performed by queens, intermediates may start a new colony although their offspring will be entirely males, and workers may participate in nest building activities during the season. This will show that the psychological impulse of this activity is not tied up with the physiological condition of females. It was shown by Deleurance (1948 a) that the removal of ovaries did not affect the social behaviour of wasps. Castrated females were able to collect constructive material and to carry out all other social functions to the extent that they were not recognisable from intact ones. Deleurance (1946) has also shown that intermediates do not occur among colonies during the active brood-rearing season so long the queen is present. And although it has been shown that the disappearance of the latter evokes ovarial development in some workers, yet it is still unknown what conditions, physiological or psychological, that instigate such a change in some particular workers. However, it is the occurrence of intermediates and auxiliaries, together with the continuous founding of new colonies during and towards the end of the active season that cause one to think that swarming is not unlikely to occur among *Polistes* wasps.

Factors which may possibly contribute to the production of different types of female are summarized by Richards *et al* (1951); the most important of which is what he calls the cyclical factors. One of these factors which still needs further study is the age of the queen, her life is relatively short and her oviposition rate may be affected at the later part of her life and so a change in the larva/worker ratio is produced. This will inflict upon the larvae a serious change in feeding and a conceivable variation in

the trophallactic balance. Another factor is the cyclical development of some secretion, as there is in the workers of honey-bee.

The appearance of males certainly determines the time when auxiliaries occur. The present work shows that males are present and so copulation may take place at all times of the active brood-rearing season. Cumber (1951) arrived to the same conclusion in *P. humilis*, but Rau (1946) gives the date of July 5th, for the first appearance of the male caste in *P. pallipes* and *P. variatus*. But there is an agreement among authors that males can possibly be among the early products of the queen. In the present work a male was found the first to emerge among the early brood of a queen, and this was on May 15th. This marks by no means the first appearance of adults in all seasons, as weather conditions during the preceding winter determine the time when brood-rearing will first start and also the speed of development of both the immature stages and the colony as a whole. It has been shown in nest CC, Table I, that all immature stages were found and of the pupae there were three ones at the end of their pupal stage and which could have given rise to adult workers on January 13th, or 14th, had this nest been left and the workers forced their way out, and had the then prevailing warm spell extended for 2 or 3 days more. In 1950 the last male was caught on the wing on November 27th, no males were among the capture during the following winter months; but on their relative occurrence during the season there are no further informations at hand. It has been shown that during winter only stylopized workers are present.

It has been pointed out by several workers that a colony may be founded by several queens which co-operate in building up their nest. But later on the reproductive function is exclusively performed by a single dominant queen; the ovaries of the others become more or less suppressed. Observation which supports this point is still lacking, there is no direct evidence as when and how the reproductive function of the associate queens is suppressed, nor whether is there any sign of division of labour in an association. In the present work the domination theory was not substantiated. It was found that suppressing the reproductive function of queens at the outset of the active season brought about some changes in the ovarioles which were not encountered in associate queens.

Stylopization, other than producing asymmetry, curtaling the life of adults and very often preventing copulation in hibernating females it does by no means hinder the progress of a colony; heavy stylopized but very populous colonies were found. As regards the number of generations occurring throughout the year the observation at hand suggests the occurrence of two generations of *Xenos vesparum* Rossi, during the host's brood-rearing season and a third which extends throughout the remaining part of autumn

and winter months. *Eoxenos*, the free living form, has only a single generation each year (Clausen, 1940); and other forms of stylops are known to have not more than two generations a year in other parts of the world (Pierce, 1909). Super-parasitism is a common occurrence among wasps; this was found in some cases to result in the death of the host which brings about the death of the contained parasites. The failure of the parasites to discriminate between parasitized and unparasitized hosts is in several cases known to be detrimental. But in stylopization the internal organs of the host other than becoming considerably crowded they remain invariably intact; and consequently the host may tolerate a very high number of parasites. It is the opinion of Salt (1931) that there is a connexion between nutrition and the effect of stylopization, and suggests that such a relationship is brought about through the influence of the parasite upon the metabolism of its host.

The foregoing observations suggest that it is only the triungulinids which attack the most advanced larval stages of their host at the end of its active season that can survive the winter without causing the death of their host. Naturally super-parasitism has a bearing on the ability of the host to survive the winter.

It is worth noting that *Xenos* is unlikely to attack *Vespa orientalis* F. in our district. 2243 workers and 12 males were collected and examined during September, October and November 1951, and no Stylopids were observed. However, Professor Dr. H. Priesner informed me that he has recorded the occurrence of stylopization in other hymenopterous insects, i.e., *Stizus bizonatus* Spin., and *Sphex (Calosphex) niveatus* Duf., caught at Fayed (Suez Canal zone) in 1943. Furthermore, in Mr. Alfieri's Hymenoptera collection, there exist four *Ammophila*, two of which collected at Gebel Asfar in May, the other two in the Fayoum in February. Three of these specimens show an adult *Xenos* female exiting from the end of the abdomen, and a fourth specimen contains a male parasite.

X. SUMMARY

1. The population density of wasps has been studied during the active brood-rearing season and the captures during autumn and winter have been analysed.

2. Nest building activities, reproduction, storing honey, and brood-attendance can be evoked during winter when weather conditions are well suited. Adult wasps can emerge from their nests as early as mid-January.

3. Building up new nests is essentially instinctive; it is neither tied up with the physiological condition of females nor is it performed by a certain

type of female. Queens, auxiliaries, intermediates and workers maintain nest building activities, but signs of division of labour are still lacking.

4. Associate queens lay their eggs at a normal rate and no support of domination can be observed.

5. Males were found to occur at all times during the season but totally disappear during winter. This has a bearing on the appearance of auxiliaries during and towards the end of the active season, and also on the possibility of « swarming ».

6. The effect of stylopization on the duration of life in wasps and on maintaining sterility among workers was studied. The first appearance of triungulinids and the biology of *Xenos vesparum* Rossi, were ascertained under our local conditions.

7. The parasite has presumably three generations each year : two occurring during the active host season and the third extends throughout winter.

8. It has been suggested that it is only the trungulinids which attack the most advanced larval stages of their host at the end of its active season that can survive the winter without causing the death of their hosts. The rate of super-parasitism has also some bearing on the capability of the host to cross the hibernating season.

XI. APPENDIX

It has long been thought that a *Polistes* colony may be founded by several co-operating queens, but later in the season the reproductive function is exclusively performed by a single dominant queen, and the ovaries of the others become more or less suppressed. Observations which support this point is still lacking. A further study of several *Polistes* nests during July 1952 showed that colonies normally have more than one queen.

The first nest was for *P. gallicus* collected on 12th July 1952. It was a small nest (96 cells) and there were twelve adults, two of them were queens and the others were workers. 25 eggs, 56 larvae and 7 pupae were also present.

The second *gallicus* nest was collected on the same day. It contained 149 cells and there were 24 adults : 10 queens, 3 auxiliaries, 2 intermediates, 8 workers and one male. The nest contained also 25 eggs. 94 larvae and 28 pupae.

Samples of adults of two more *gallicus* populous colonies containing different immature stages were collected on 15th July 1952. Of the first colony 13 adults were examined and they were : 3 queens, 7 workers and 3 males. Of the second colony 21 adults were examined and they were : 7 queens, 2 intermediates, 11 workers and one male.

As for *P. foederata* samples of adults of two colonies containing different immature stages were collected on 15th July 1952. 20 adults of the first colony were examined and they were : 7 queens, 2 intermediates, 10 workers and one male. Of the second colony 26 adults were examined and they were: 5 queens, 2 intermediates, 15 workers and 4 males.

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The biology of some Hemiptera-Homoptera (Auchenorhyncha)

(with 24 Text-Figures and 2 Tables)

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I. INTRODUCTION

Going through the literature it was found that very little is known on the biology of the *Hemiptera-Homoptera* (*Auchenorhyncha*). Fox Wilson (1937) attempted to rear *Graphocephala coccinea* (Forst.), but he stated « ... but we so far failed to induce this leaf-hopper to oviposit under laboratory conditions ». Hassan (1939) gave a short account of some points in the biology of *Delphax fairmairei* (Perris). This is possibly due : (1) to difficulties in rearing this group of insects under laboratory conditions; (2) to difficulty in detecting the oviposited eggs, which are not externally visible in some instances, e.g. *Cicadella notata* (Curt.) and *Cicadula quadrinotata* (Fab.) ; (3) to the wide variation in host preference of the different species and their choice of different plants for oviposition and for feeding, as will be shown in *Tettigoniella viridis* L. ; and (4) to the occurrence of some species on a variety of plants, though they mainly feed on particular ones. This demands accurate observations and a test, for the feeding habits as was found in *Cicadella notata* (Curt.) which occurs on several grasses and weeds, but appears to feed on *Hypochoeris radicata* though laying eggs in the weeds, or, again, in *C. quadrinotata* (Fab.) which was observed on different grasses including *Dactylis glomerata*, though the latter is the main host plant.

Delphax fairmairei (Perris) which Hassan (1939) found to feed on grass and lay eggs in the same host under laboratory conditions appears, according to my field observations, to feed on grass but to lay eggs in blackberries in two different ways, the shapes of the eggs varying with the site. There is a serious difficulty in detecting the eggs inside the plant tissues. This was found with *Graphocephala coccinea* (Forst.). Many attempts in the summer of 1947 failed to induce these hoppers to lay eggs under laboratory or outdoor conditions. Later on, it appeared that they lay their eggs in the sepals of the summer-autumn dormant flower-buds of *Rhododendron*, and these buds were not provided during rearing.

The object of the present work was to study the bionomics and life-cycles of those local *Auchenorhyncha* which were found most convenient for detailed observations.

Attention was also paid to their egg-parasites and the parasites of the nymphs and adults, and to the effect of parasitism by *Pipunculids*.

The majority of the nymphal instars of the species studied have been described here for the first time.

II. TECHNIQUE

1. Collecting

For collecting Jassids and Delphacids three methods were tried.

(a) Sweeping the grass with an insect net or fairly small mesh did not give satisfactory results. Jassids drop from plants when disturbed and conceal themselves in the dense bottom layer of grass. Moreover, the ring of the net cannot reach the very bottom stems and leaves. On the other hand, a net was helpful in collecting Jassids from trees and shrubs, excluding those with thorns.

(b) A sucking-tube was found the best for collecting both Jassids and Delphacids from grasses.

(c) A trial was made by spreading a four-feet square white towel on grass. Jassids were pursued towards this sheet and were picked up with the sucking-tube.

a. Under laboratory conditions

2. Breeding methods

(1) A tube (fig. 1) $1 \times 3\frac{1}{2}$ inches was made from a cellulose sheet of 0.4 mm. thickness. The sheet was placed on a graph paper and perforated with a hot pin. The holes were made about one millimeter in diameter. Then the sheet was rolled round two cork stoppers fixed at the ends of the tube and the edge was stuck with a strip of adhesive cellulose tape. One

of the two corks was $\frac{3}{4}$ inch long to fit a 1×3 inches glass specimen tube. A hole was made in the centre of this cork. The cork was split into two longitudinal halves and the two halves stuck together on one side with a piece of the adhesive tape, so keeping the two parts of the cork assembled together, but enabling them to be opened to fit round the stem of the plant. A small plant of grass with a fairly small root was grown in the glass specimen tube by filling it with two inches of soil. The grass was watered and the tube was closed with the $\frac{3}{4}$ inch cork. The space between the stem of grass and the cork was closed with a small piece of cotton-wool. The perforated cellulose tube was fixed to the one inch cork, and its opening at

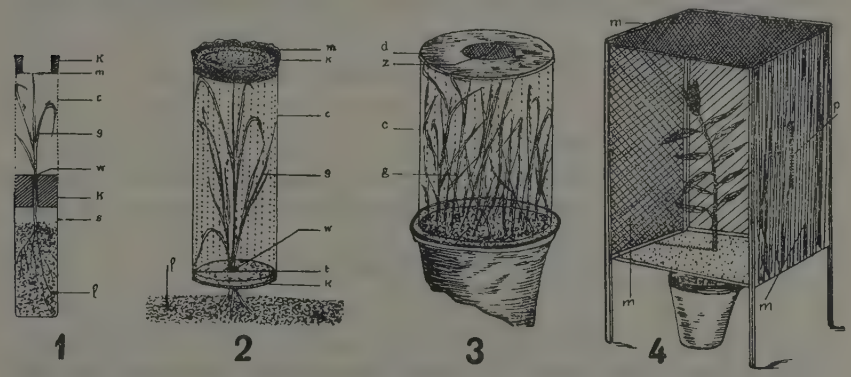


Fig. 1: A cellulose tube fixed to a glass tube (c, cellulose tube; g, grass; k, cork; l, soil; m, muslin; s, glass tube; w, cotton wool), $\times \frac{1}{4}$. — Fig. 2: A cellulose tube fixed to grass (c, cellulose tube; g, grass; k, cork; l, soil; m, muslin; t, slit in cork; w, cotton wool), $\times \frac{1}{3}$. — Fig. 3: A cellulose cage fixed to a pot (c, cellulose cage; d, tin lid; g, grass; z, wire gauze), $\times \frac{2}{5}$. — Fig. 4: A muslin cage (m, muslin; p, zipp), $\times {}^{2}/_{13}$.

the top was closed with a cork having a hole $\frac{3}{4}$ inch in diameter. The hole was covered by sticking a piece of muslin at the bottom of the cork. This method had the following advantages:

(a) It kept the host plant (grass) green and fresh for over a month. Thus, it saved the trouble of changing the food periodically. Also, it kept the insects under conditions as near as possible to those under which they live naturally.

(b) The method used by Hassan (1939) for rearing Delphacids in specimen tubes, one fifth full of wet sand with four pieces of grass stems planted in it and with the tube covered by a piece of muslin, has been tried for breeding Jassids and Delphacids and was found unsatisfactory. The Jassids dealt with are small and of the macropterous form. The elytra are rather thin and easily stuck to the sides of the glass tube owing to condens-

ation of water-vapour which occurs when the soil is damp enough to keep the plants fresh. Excessive humidity was avoided in the present work by isolating the stem and leaves of grass from the wet soil with the cork at the bottom. Moreover, sufficient ventilation was provided through the perforated cellulose tube, and the muslin fixed to the bored cork at the top.

(c) The study of the incubation period of eggs was possible because the plants kept fresh for a considerable time after the eggs hatched. The parts of grass containing eggs in Hassan's method, when they had been kept for few days, became dry and caused a high mortality among the eggs.

(d) This double-tube method facilitated the microscopical examination of the different parts of grass and of many aspects of the behaviour of the insects.

3. Fixing cellulose tubes to grass growing in a pot

(Fig. 2)

A tuft of grass was cultivated in a pot 13 inches in diameter. Cellulose tubes $1\frac{1}{2} \times 3\frac{1}{2}$ inches were used. These were prepared as already described and fixed to the grass stems. A pair of insects were confined in each one.

4. The stock cellulose cage

(Fig. 3)

A perforated cellulose cylinder 8×12 inches with 2 mm. holes was fixed over some grass growing in a pot 13 inches in diameter. This was covered with a lid which was provided with a disc of wire gauze at its centre. This cage was used for keeping a stock of insects for general study.

5. The muslin cage for rearing Graphocephala coccinea (Forst.)

(Fig. 4)

A big cage was made for the purpose of studying the habits of *Graphocephala coccinea* (Forst.). It had a wooden frame $22 \times 22 \times 47$ inches covered with muslin on all sides except the front which was a transparent sheet of cellulose, through which the insects were watched. A zipp, 12 inches long, was sewn to the centre of the left side of the cage so that insects could be put into or removed from the cage through this opening. A *Rhododendron* plant growing in a 13 inches pot was inserted from the bottom of the cage through a slit made in the muslin. Then the slit was sewn right to the stem leaving no holes in the bottom.

6. Test-cage for host plants

As it was found difficult to discover the species of grass which was the real host plant of a given Jassid a special cage was made for this

purpose. The measurements of the cage were $9 \times 12 \times 10$ inches. The side walls were made of glass, with the bottom 3 inches of wood to hold a layer of soil 3 inches deep. The bottom was perforated to allow drainage, and the top was covered with muslin fixed to a wooden frame. A hole was made in the muslin top through which a glass funnel with a fairly long stem was fixed for watering the grass without opening the cage.

7. The glass specimen tube method

For rearing *Delphax fairmairei* Perris, a glass specimen tube 2×1 inch was used. A pad of wet cotton-wool was put at the bottom of the tube and was covered by filter paper so as to prevent the tarsi of the insects from being caught. The tube was closed with muslin fixed to the opening of the tube by a cork stopper with a hole at its centre. A few pieces of grass stems and leaves were kept in each tube.

Breeding *D. fairmairei* Perris by this method was successful.

8. The glass pot method

A glass pot $2\ ^3/_8$ inches in diameter and $1\ ^3/_8$ inches high was covered with a glass disc which had a $1\frac{1}{2}$ inches diameter hole at the centre covered with muslin stuck to the glass border by sealing wax. The glass disc was put on the top of the pot and hinged to its side by a cellulose adhesive tape. A piece of wet cotton-wool $\frac{1}{4}$ inch thick covered with filter paper was put at the bottom of the pot. Grass stems and leaves were put in as in the glass specimen tube method.

This method proved to be satisfactory for the rearing of the species dealt with in this paper, with the exception of *Tettigoniella viridis* (Lin.). For *T. viridis* (Lin.) a grass shoot growing in soil in a glass tube $\frac{3}{4} \times 1$ inch was put horizontally into the glass pot just described. Fresh sap provided by actively growing grass appeared to be essential for the successful breeding of this species.

9. Keeping the eggs in cut pieces of stems to hatch

A method was tried for keeping the eggs of *Cicadella notata* (Curt.) laid in the flower stalk of *Hypochoeris radicata*, during the incubation period under laboratory conditions. A piece of flower-stalk containing the eggs was cut obliquely with a sharp razor blade and fixed through a cork. The stalk was inserted into a small glass tube with a cork stopper on its top, having a hole covered with muslin. To the cork at the bottom 4 pins were fixed to allow the whole tube to stand in a small beaker containing a little water (which was changed daily). This method seemed to be satisfactory for keep-

ing the eggs. It delayed the growth of fungus for about 25 days, by which time the incubating eggs were just hatched.

b. Under field conditions

1. Breeding Criomorphus pteridis (Boh.) on bracken plants

A cellulose sheet of the same measurements and description as in No. 3 was rolled round two cork stoppers fixed at either of its ends and the side edge was stuck temporarily with a cellulose adhesive tape. Then the tube was immersed in a hot water-bath to enable it to be moulded into the required shape. The two cork stoppers were bored in the centre, having a hole $^3/_8$ of an inch wide. Each was then split into two halves. Each pair of halves was assembled and stuck on one side with the adhesive cellulose tape. The stoppers were dipped in hot wax for reproofing. The cellulose rolled sheet was fixed round the stem of bracken plant and the split stoppers fixed at each end of the tube opening round the stem of the plant. The side of the tube was stuck with the adhesive tape. Then the corks were removed, and the tube was stapled with two stiches to keep it firmly fixed so as to stand changes in the weather. The cork at the bottom was fixed to the tube and a piece of cotton-wool was wrapped round the stem and the cork inside the tube. Then the insects were put into the tube and the cork at the top was fixed. The opening between the stem and the upper cork was also closed with a piece of cotton-wool. A round cellulose disc acting as a shelter was fixed to the upper cork by making a $^3/_8$ of an inch hole at its centre and a slit running from the centre to the periphery (one side only). Then the disc was fitted round the plant and fixed to the upper cork with two pins. These discs were originally intended to keep off rain but they were also useful as landmarks when fixing the tubes.

2. Breeding Graphocephala coccinea (Forst.)

Cellulose tubes were made in the laboratory and slipped over the tips of the growing shoot of *Rhododendron*. The number of leaves kept in each tube was reduced according to its size. The cork at the bottom of the tube was fixed to it in the way already described. The top of the tube was closed with a perforated cork and muslin.

III. MATERIAL STUDIED

1. Criomorphus pteridis (Boh.)

This Delphacid is found commonly on bracken (*Pteridium aquilinum*) which is its only host plant. In winter some nymphs were collected and fed

on grass under laboratory conditions with a temperature range of 20°-26° C. The nymphs (fig. 5) became active, but did not feed and died after 2 days.

The insects feed on either side of the leaves though the majority occur on the underside and on the stems of bracken. The punctures caused by their mouth-parts could not be detected easily by the naked eye, when fresh, but later on pinkish spots appear. Also the egg-slits are easily seen scattered in the stem and the midrib of the compound leaf. These slits appear as short lines, pinkish or brown in colour. Adults and nymphs emerge in the first half of June, females being followed by males

The adult

Edwards (1896) gives a description of the adults, but his description was possibly made on old dry specimens because of inacuracy as regards the colour of the legs and the thorax which in fresh adult individuals are coloured as follows:

♂. Fore and mid coxae black; trochanters light brown; femur and tibia light brownish yellow in colour. The first two tarsal segments brown, but the last much darker (nearly black). The tips of the bristles of the hind tibia and those of the spur are dark brown or black. Thoracic sternites nearly black.

Criomorphus pteridis (Boh.)

Fig. 5: Nymph, ×17.5. — Fig. 6: Adult, ×15. — Fig. 7: Eggs in a piece of bracken-stem, ×20.

Macropterous males are scarce, as only three individuals were collected at Silwood Park on June 15th, 1948. In the brachypterous form there is no trace of the articulation of the aborted hind-wings (fig. 6).

♀. Fore and mid coxae are light brownish, but the hind coxae are brown in colour. The rest of the legs are of the same colour as in the male. Thoracic sternites brown.

Copulation

Males face the apex of the female's abdomen. They move slightly forwards and vibrate their elytrae, raising them upwards and downwards in an acute or right angle to the body. The female was seen feeding during this time, and it seemed to be unready for copulation because it refused copulation. It pushed its hind leg backwards at the male, making several strokes. The male made some attempts to excite the female by going round it, walking laterally with its face round the margin of the female's body and vibrating its elytra. When it touched the female, the latter moved its fore or hind legs pushing the male away. After a considerable time the male left the female and wandered about the leaves. Then, it again attempted to excite the female. This was observed repeatedly with different couples. I had no chance to see the pairs in copulation.

Pre-oviposition

Twelve pairs which emerged on May 22nd 1948, were confined in separate cellulose tubes fixed to bracken plants in the field. Five individuals started laying eggs on 5th June, i.e. approximately 14 days.

Oviposition

The female makes an egg-slit with its ovipositor either in the stems of bracken, or in the stalks or midribs of the compound leaves. A single female laid about 100 eggs in 41 egg-slits, either one, two (usually) up to five per slit.

Oviposition took place in the field from the first week of June.

Incubation period

The eggs which were laid on 5th June 1948 hatched out on 22nd July, that is 47 days under field conditions.

The egg

Eggs (fig. 7) are hyaline, whitish in colour, oval in shape, curved, and tapered slightly towards the operculum, about one millimetre in length, and 200 μ in width. They are inserted within the plant in an egg-slit which is made vertically in the direction of the plant veins. The slits are either single or in pairs close and parallel to each other, both on more or less the same level. After some time the slits become brownish pink in colour and later turn black. The cone like caps of the eggs which cover the micropiles sometimes appear on the surface of the slit but in some instances they are covered with a transparent or white gum-like secretion.

In the last week of September 1947, 500 egg-slits were examined to determine the hibernating stage, the arrangement and number of eggs in the slits, and to search for egg-parasites. This examination was really too

late in the season for egg-parasites, but some which had failed to emerge or which left traces of their development were nevertheless found.

270 (54%) of the above mentioned egg-slits were found single, and 230 (46%) paired. 91 (18.2%) of the egg-slits contained one egg, 300 (60%) two eggs, 100 (20%) three eggs, 4 (0.8%) four eggs, and 5 (1%) five eggs. The condition of these eggs at this time of the year was as follows: 641 (62.11%) hatched eggs, 35 (3.39%) alive eggs, 145 (14.05%) dead eggs, and 211 (20.45%) parasitized eggs.

The relative high percentage of hatched eggs induced the author to undertake a thorough search of the nymphs.

Hibernation

In the first week of October, about 400 nymphs were collected. Some were found on the few remaining green plants of bracken and the rest in the thick layer of dead leaves and stems lying on the ground, presumably their proper shelter for hibernation. Another 400 nymphs were collected from the same spot in the third week of December; the majority in the third or fourth instar; none could be seen of the first or last instars. The hibernating nymphs (Fig. 7) were successfully kept alive during winter in cellulose cages with growing moss at the bottom, and a few dry stems and leaves of bracken, being lightly watered every now and then. Some others were kept on growing grass in a plant-pot, the grass being surrounded with a cage.

On 22nd April 1948, bracken buds were obtained by digging from the soil. Some of the hibernating nymphs were successfully fed on these buds, under laboratory conditions. In a few hours some of them moulted.

On 1st May limited number of bracken shoots appeared above soil about a foot in height. Some of the hibernating nymphs started to feed on these new plants. In the third week of May the adults of *C. pteridis* emerged, some of which were collected on 18th of that month.

Number of generations and seasonal occurrence

C. pteridis (Boh.) has one generation a year. The adults emerge in the second half of May and die by the end of July, though six females were collected on 9th August 1947. The eggs were found from the first week of June, decreasing to very small numbers in the last week of September. The nymphs emerged from 22nd July (1948). They pass the winter in the second, third or fourth instar.

Parasites

Anagrus spec. (Mymaridae)

This tiny species has been found parasitising the eggs of *C. pteridis* (Boh.). It seems to quite agree with *Anagrus dilatatus* (Enock, i.l.) accord-

ing to Mr. W. D. Hincks, but it is not safe to use this name at the moment. Specimens have been deposited in the collections of the Commonwealth Institute of Entomology and the Manchester Museum. No external symptoms of this parasite indicated its presence before the adults escape from the egg-shells. When the adult parasite emerges, it gnaws its way through the stem making an oblique tunnel which opens to the exterior in a clear-cut round hole located on one side of the egg-slit, when it is a single slit and on the outer side of the egg-slits in the case of a pair of slits. It never comes out straight through the egg-slit of the *Delphacid*.

In some instances a round patch lighter in colour than that of the bracken stem was seen on the outer side of the egg-slit of the Delphacid. This patch indicated the presence of the adult parasite, which was found dead after it had gnawed its tunnel nearly up to the surface of the stem. The emerged adult parasite leaves behind the chewed particles of the stem, a portion of which is left in the egg-shell.

Not more than one adult *Anagrus* spec. was found in each egg. All the eggs of one slit are not always parasitised. I have never seen more than two holes beside the single slit though 20% of the egg-slits contained 3 eggs in each, and not more than 2 holes in each outer side of a pair of slits. The examination of 1032 eggs of *C. pteridis* (Boh.) revealed the presence of 211 eggs parasitised by *Anagrus* spec. (20.45%); but only 48 escape holes were found. In other words the mortality among these egg-parasites is 77.3% which sounds very high. This could be probably attributed to the relation between the date of the adult parasite emergence and the nature of the plant. The plant, while green, has soft tissues but when it is about to die off or is dead, its cortex hardens so that the adult parasites which emerge from the late parasitised eggs of *C. pteridis* (Boh.) may find difficulty in gnawing their way out. The examination of these egg parasites was made late, at the end of October 1947, and all the plants examined were either semi-dry or completely dry.

Pipunculus semifumosus Kow. (Pipunculidae)

On 13th July 1947, thirty females of *C. pteridis* (Boh.) emerged. Three days later five of them were found dead, being parasitised with Pipunculids (Diptera) larvae. These larvae pupated next day but none emerged. On 21st April 1948 three of the hibernating nymphs of *C. pteridis* (Boh.) were collected and found parasitised. The larvae left their hosts on the 24th and pupated the next day. The adult flies emerged on 14th May 1948, and were kindly identified by O. W. Richards as being two females of *Pipunculus semifumosus* Kow. and a male probably of the same species.

It is obvious that Pipunculid larvae found at this time of the year (21st April) must have been in diapause during winter, possibly either in the egg or in the larval stage.

2. Delphax fairmairei Perris

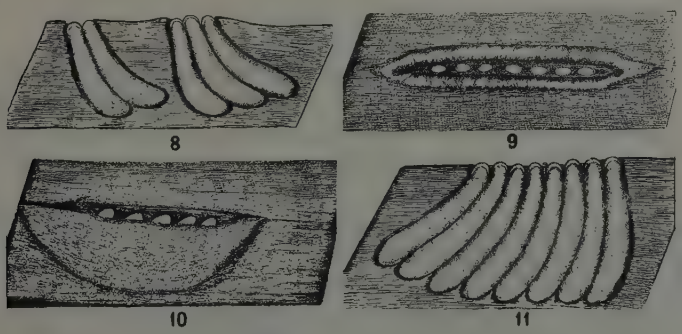
This Delphacid was collected from those parts of the field where blackberries, rushes (*Juncus effusus*) and *Holcus* were in association. It seems that *Delphax fairmairei* Perris occurs more often in wet places than in dry ones. The collections were made on the west side of Silwood Park in wet ground adjacent to a stream.

Hibernation

On 24th March 1948, examination of runner and aerial stems of blackberry revealed the presence of the hibernating eggs of *Delphax fairmairei* Perris. Hassan (1939) refers to the presence of the eggs in the field from the second half of August to the first half of May, in the stems of grasses. In my opinion blackberry is probably the more important oviposition site.

The egg

The egg (fig. 8) is hyaline, yellowish white in colour, oval in shape, and of variable curvature. The egg turns orange when the embryo is about



Delphax fairmairei Perris

Fig. 8: Eggs, ×20. — Fig. 9: Egg-slits (top view), ×20. — Fig. 10: Egg-sac, ×20. — Fig. 11: Egg-slits (longitudinal section), ×27.5.

full grown. It is 800 μ in length and tapered slightly towards both ends (fig. 8).

The blackberry stems contained eggs of *Delphax fairmairei* Perris of two different shapes; further, there were two methods of oviposition, as follows:

(1) Eggs are laid in a semi-hard sac (fig. 9) located underneath the mesophyll layer of the runner stems. Few egg-sacs were found in the aerial stems of blackberry, and none in the petioles. This sac opens to the exterior through an egg-slit 400 to 500 μ long; the margin of the slit is hardened, brown in colour and oval in shape. The eggs are deposited obliquely to the veins of the stems. The sacs show as a prominent tumour which is slightly lighter in colour than the stem. The tumours vary in size according to the number of eggs which they contain. The conical caps covering the micropiles of the eggs protrude from the egg-slits. A gum-like secretion often covers the opening of the egg-slits. It appeared that the egg-sacs are found in rows with from 2 to 11 egg-sacs in each. Single egg-sacs were also found scattered about. The majority of the egg-sacs are located in the edges where the pentagonal sides of the stem meet. The longest row contained 26 egg-sacs and was 37 millimetres long and there were fifteen slits which had no indication of egg deposition. This might have been due to unseccessful attempts at oviposition, as found in several other places in the stem.

From 1 to 5 eggs were found overlapping in the egg-sac, but 1, 2 and 3 eggs per sac were the more frequent numbers. Examination of 200 egg-sacs showed that 37.5% contain single eggs, 51% two eggs, 8% three eggs, 3% four eggs and 3% five eggs.

A piece of runner, 45 cms. long, was examined and revealed the presence of 253 eggs.

(2) Eggs may also be laid right inside the runners, the aerial stems and leaf-stalks of blackberry, being placed perpendicular to the plant surface. Unlike the egg-sacs, here the eggs in slits show no swellings. The eggs look different in shape and length from those laid in the sacs. This might be attributed to the difference in the effect of the plant tissues on the eggs. Those laid in sacs are superficial and lie under a light pressure of the plant cuticle. Whereas, those laid through deep in the stem might be subject to greater pressure. The eggs found in the stems or leaf-stalks are hyaline, oval in shape and tapered slightly towards the operculum. The egg is about 900 μ in length and slightly curved.

The egg-slits (figs. 10 and 11) are parallel to the plant veins and many are found in one line or in several parallel lines. The egg-slit is 1.2 mm. to 3 mms. in length. The slits have a hardened brown edge with the tips of the eggs showing through the opening. This opening is often covered with a gum-like secretion. The eggs are found in rows overlapping each other. The egg-slits contain from 3 to 13 eggs per slit. One hundred egg-slits were examined to show the distribution of eggs in the slits. 10% of the egg-slits contained three eggs, 9% four eggs, 6% five eggs, 16% six eggs, 25% seven

eggs, 16% eight eggs, 15% nine eggs, 1% ten eggs, 1% eleven eggs, and 1% thirteen eggs. Thus, the six, seven, eight and nine eggs per egg-slit were the more frequent.

Adults were reared from eggs in sacs and from eggs in slits and some males of each were submitted to Dr. W. E. China who kindly determined them as *Delphax fairmairei* Perris.

On 10th April 1948, eggs of *D. fairmairei* Perris were removed from the stems and put in a glass pot with wet cotton-wool covered with filter paper. Some of the eggs were in direct contact with the filter paper and the others were kept with small parts of the blackberry stems leaving the eggs exposed on one side. The avoidance of large pieces of plant stems and the removal of the eggs from the stems minimised the trouble caused by fungus infection. Eggs were kept under laboratory conditions with a temperature of 20-25° C. The majority of the eggs hatched out after six days.

Duration of the nymphal instars

Ten eggs of *Delphax fairmairei* Perris hatched on April 16th 1948, 17 on the 17th, 4 on the 18th, and 11 on the 19th. The 51 nymphs were reared under laboratory conditions with a temperature range of 19-25° C.

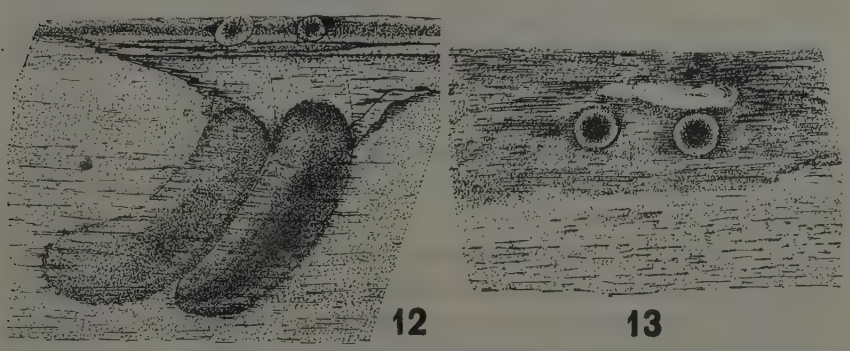
The duration of the 1st, 2nd and 3rd nymphal instars was 3-5 days each. The 4th instar from 3-6 days and the 5th from 6-9 days.

The total duration of the nymphal period was 22-27 days (mean 24.2).

Parasites

Anagrus incarnatus (Hal.) (Mymaridae)

On 24th April 1948, some eggs of *Delphax fairmairei* Perris were found parasitised with *Anagrus incarnatus* (Hal.), kindly determined by Mr. W. D. Hincks. The parasitised eggs are orange in colour with the mecon-



Anagrus incarnatus (Hal.)

Fig. 12: Escape holes (longitudinal section in stem of blackberry), ×50. — Fig. 13: Escape holes (top view).

ium showing through the egg-chorion. The larva and pupa of this parasite rotate inside the egg-shell of the Delphacid egg, when stimulated by light or heat. The adult parasite, when full grown escape through a round hole which it gnaws (figs. 12 and 13). In the case of the eggs which are laid in superficial sacs and just under the cuticle of the blackberry, the parasite usually makes its hole at the posterior end of the egg. Consequently the holes of the parasite in this case are not far from the eggs, unlike those found in the egg-slits where the adults gnaw a tunnel quite a distance from the free extremity of the embedded eggs. The head of the parasite-embryo was usually found at the posterior end of the Delphacid egg, and the parasite breeds singly in the egg.

3. Cicadula sulphurella (Zett.)

The adult female of this Jassid is about 5 mms. long and the male is 4 mms. Both sexes have a distinct sulphur-yellow colour and the crown bears no colour pattern. The venation of the elytra stands out as an even brighter yellow.

Host plants and habitat

This species feeds apparently only on *Holcus mollis* for it was never collected by the author from any other grass. It seems to prefer either semi-dry or wet places in fields where the host plant occurs.

C. sulphurella (Zett.), like other leaf-hoppers, is active and jumps quickly when disturbed. It has a curious habit of lateral movement when walking. Some individuals were watched in a cellulose cage. They never walk in a straight line, but go around the sides of the cage upwards or downwards. This behaviour is similar to that seen in the field on the plants. When they are in danger they immediately retire to the opposite side of the leaves or stems in a quick lateral movement. When they cannot escape the danger they hop to a distance of a foot or fly to a near plant. If they are still disturbed they drop from the leaves of grass and are concealed underneath the mat of grass at the bottom. As to their feeding habits, *C. sulphurella* (Zett.) feed on either side of the leaf of grass or its stem.

All my collecting was made at the Imperial College Field Station, Silwood Park, Sunninghill, Berks.

Nature of injury

As many different species of leaf-hoppers live together with *C. sulphurella* (Zett.), it is rather difficult to appreciate the amount of damage done by this species. However, during my laboratory breeding experiments, a cage was set up for keeping a stock of about 200 individuals of these Jassids and hence considerable damage to the grass was noted. Three days after

having put the adults into the cage, the grass showed a lack of vigour and the leaves had a mottled whitened appearance. A few days later, growth was obviously retarded and the leaves turned yellow, wilted and died.

Hibernation

A weekly collection of *C. sulphurella* (Zett.) was made in 1947 from the beginning to the end of September. 210 females were collected during the first week, 550 females and 3 males in the second week, 120 females in the third week, and 50 females in the fourth week (total 933 individuals). Sixty (6.4%) of these were found parasitized with Pipunculids (Diptera) larvae. No *C. sulphurella* (Zett.) could be obtained in the first week of October.

The figures for the first week of September are not really comparable because the exact locality in which *C. sulphurella* (Zett.) occurred and the favourite host plants were not known to me at that time. From the second week onwards, the decrease in the number of adults is clearly seen. On 6th September 1947 one hundred females were kept in a cellulose cage fixed to some grass growing in a pot. Eight cellulose tubes were also fixed to grass and five females were put in each tube. Most of the individuals were actively ovipositing under laboratory conditions until 15th. They started to die off from the second half of September, and by the end of the month no adults were alive. This agrees with the above data, for the adults were getting scarce in the field at the end of September and none could be seen in the first week of October. Consequently, the eggs appear to be the hibernating stage of this Jassid.

A cellulose perforated cage covering some grass containing eggs and kept indoors, or a cellulose perforated tube fixed to a stem of grass growing in a pot and the tube left lying between other green leaves of grass, were the best methods which allowed to keep the eggs viable during the winter.

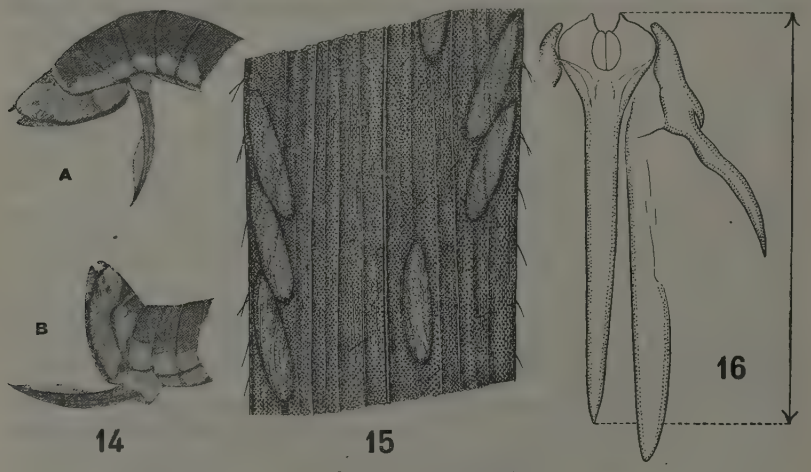
The hibernating eggs were all kept indoors in a partly ventilated room without any heating. The eggs started to hatch on 4th May 1948.

Oviposition

When an adult female begins to lay eggs, it wanders about the leaf of grass, chooses a fresh green part either of the blade or sheath, and feeds before commencing to insert any eggs. It then stops for an instant, getting ready for oviposition. The ovipositor valves exhibit, whilst still horizontal, protrusion and retraction alternately. The saw-like valves protrude from their case downwards, lying perpendicular to the plant surface. In this stage the Jassid slopes downwards in either direction from the point of attachment of the ovipositor and the last sternite (fig. 14).

It then holds the plant firmly with its fore legs, balancing its body as on a tripod, making a third leg with the tip of the saw-like valves. Sometimes, the hind legs exhibit a free movement in the air, keeping away from the leaf or just touching the hairs of the plant. In the mean time the mid legs just touch the leaf surface and are occasionally lifted up. It then begins to force the ovipositor through the tissues of the leaf. The power used in pushing the ovipositor through the cuticle is due to the muscles attached to it, partly to the weight of the Jassid concentrated on this point of the tripod and partly to the upward and downward movement of the saw-like valves which cut the tissues of the leaf. The parts of the serrated pair of valves when in action do not work alternately as in the saw-fly. This is due to their fusion proximally for about a third of their length.

In some instances the Jassid fails to insert its ovipositor in the chosen place. It thus makes several trials, proceeding a step forward each time until it succeeds. When it fails again it bends the ovipositor laterally and



Cicadula sulphurella (Zett.)

Fig. 14: A, first ovipositing site; B, second ovipositing site (×15). — Fig. 15: Eggs in a leaf of *Holcus mollis* (treated with 10 % caustic potash), ×42. — Fig. 16: Length of ovipositor, ×21.

obliquely, usually meeting softer tissues through which the ovipositor can be pushed more easily.

The ovipositor valves exhibit a continuous saw-like movement before laying the egg, clearing a much wider space than that of the egg, in different directions parallel to the leaf surface, either in the cylinder sheath or the flat blade. Clearing a wide space to provide a proper pouch for the egg,

seems to be necessary. The ovipositor is flattened in the same place as the leaf cuticle. Thus, unless a space wider than the egg diameter is cleared, the latter will be squeezed after the ovipositor is withdrawn by contraction of the stretched leaf cuticle. As the Jassid egg appears to be rather soft, squeezing might damage it.

Laying an egg took from one and a half to about ten minutes. The long time for laying an egg in a few cases was due to disturbance by other individuals kept in the same petri dish.

When a pocket has been made the egg runs from the oviduct through the ovipositor and into position. The ovipositor leaves a longitudinal slit of about 0.46 mm. which closes during the growth of the leaf, though some slits in the margins of the leaves were seen open even after the leaf died.

The egg

The eggs of *Cicadula sulphurella* (Zett.) (fig. 15) are hyaline, whitish in colour, oval in shape and tapered slightly towards the operculum. They measure from 1 to 1.33 mm. in length. They are usually laid individually underneath the upper or lower cuticle, either in the blade or sheath of the leaf, whereas in a crowded culture of *C. sulphurella* (Zett.) from 2 to 7 eggs were found overlapping one another. A piece of grass containing eggs was treated with 10% warm caustic potash for a few seconds to remove part of the chlorophyl to show the position of the eggs in the leaf properly (fig. 14). The eggs frequently lie parallel to the leaf veins or occasionally in an oblique position either along the margins of the leaf or elsewhere. Sometimes the egg is found located between two veins and in other instances one of the veins or both run over the egg. With experience, the position of the freshly laid eggs can be told with the naked eye by the swelling blocking the depression between the prominent longitudinal veins of the leaf. But later, the epicuticle or the exocuticle dies leaving a spot lighter in colour than the rest of the leaf.

Variation in colour pattern of nymphs

A range of colour pattern occurs in this species, from a general light yellow colour to a nearly black as in *Cicadula quadrinotata* (Fab.).

Duration of the nymphal instars

From a single egg hatched on 4th May 1948 and reared in the laboratory conditions at 19-24° C., the duration of the nymphal instars can be summarized as follows: first instar (moulted 11th May) 7 days, second instar (moulted 18th May) 7 days, third instars (moulted 23rd May) 5 days, fourth instar (moulted 5th June) 13 days, and fifth instar (moulted 20th June) 15 days.

Parasites

Pipunculus thomsoni Beker

On 3rd September 1947, an adult female of *C. sulphurella* (Zett.) was caught with other Jassids in a sucking tube, and on examination a Pipunculid (Diptera) larva was observed crawling on the walls of the tube. The *C. sulphurella* (Zett.) sample was found dead with the abdomen split open between the third and fourth tergites, all the abdominal contents being eaten. The next day the parasitic larva pupated. During the interval between the first week of September 1947 and the first week of October of the same year, 930 adult females and 3 adult males of *C. sulphurella* were collected. Of this number 60 parasitised individuals were found. Thirty Pipunculid larvae were obtained. Most of them pupated a day after they migrated from their hosts, and a few pupated after two days. The pupae were kept in glass specimen tube with a little soil. Unfortunately most of the pupae failed to emerge next summer. The single adult which emerged was kindly determined by Mr. R. L. Coe of the British Museum (Natural History).

Symptoms of parasitism

The external signs of parasitism in the adult are obvious when the larva of the Pipunculid is in about the last stage. The leaf-hopper shows a distinct swelling of the abdomen which projects behind the elytra. When the parasite is half developed a parasitised adult Jassid could be detected by an experienced eye as follows: (1) the full appearance and roundish cylindrical form of the abdomen of the host, provided the parasitised host is a male, because this might be confused sometimes with the unparasitised female which retains developed eggs; (2) the slightly lighter colour of the abdomen in the parasitised adult; (3) alteration of colour pattern is caused in some cases as will be explained later.

Behaviour of the parasitised host

On 3rd September 1947, eleven parasitised adults of *C. sulphurella* (Zett.) were kept singly in cellulose tubes fixed to glass specimen tubes with growing grass. The behaviour of these parasitised adults was watched when the Pipunculid larvae were about fully developed, and after they migrated from their hosts. The leaf-hopper with a grown Pipunculid larva shows much less activity and tends to settle on grass longer than usual. The parasite, when full grown, devours the contents of the abdomen of the host and exhibits its vermiform movement of alternate contraction and expansion. During this time the host is seen firmly fixing its claws and rostrum to the plant. Through the movements of the Pipunculid larva, waves of pressure are concentrated on the front portion of the abdomen of the

host. In almost all cases (50) the pleura between the third and fourth tergites split open and the Pipunculid pushes its mouth-parts through and makes its way out. Usually the host dies a short time after the parasite migrates from its abdomen.

Effect of parasites on the host

The colour pattern of *C. sulphurella* (Zett.) was examined in a number of parasitised and unparasitised individuals to determine the effect of the presence of Pipunculids. Seventeen parasitised females showed extreme modification, six showed moderate colour changes from the normal, and ten showed slight variation. Two parasitised males showed moderate colour changes.

The degree of colour modification may also depend on the stage at which the host is parasitised. Nymphs show greater modification than adults.

In the extreme cases of colour pattern change, the obvious thin black line extending from the base of each simple eye and marking the suture which separates the frons from the sides of the head (cheek and lora) and continues to the post-clypeus, is missing. The black colour pattern which covers about four fifths of nearly all the tergites is light brown with many irregular yellowish spots, and the coloured areas are reduced to about half. In some instances the colour pattern of the pygophor disappears completely. There is a longitudinal thin black stripe near the lateral margin of each tergite which disappears also in an extreme case of colour change. The more or less black triangle formed on the sixth to the first sternites is also missing but a small light brown spot is left on the fifth sternite in some instances.

Reduction in the size of the adult host

In a few cases the parasites failed to emerge, and their larvae were found in an abnormal position in the abdomen of the host when dissected. The mouth-parts of the parasitic larvae were directed at the caudal end of the host, though it is supposed that they can turn round freely in the empty abdomen of the host at the end of the final larval stage. The parasite attacks the host in its early nymphal stage, and certainly affects its growth, while the Pipunculid larva grows normally. Measurements of the tibae of 50 unparasitised, and the same number of parasitised females were made. Table 1 shows the frequencies obtained, the difference between the means being significant.

Reduction of the female genitalia

It was noticed that besides the tibia the female genitalia of parasitised individuals were also reduced. Twenty four ovipositors of parasitised and same number of unparasitised adults were measured each from the pointed end of the second valve to the top of its articulation with the valvifer

(fig. 16). The figures for the length of ovipositor in parasitised and unparasitised individuals show the obvious reduction in the latter. Table II shows the frequencies obtained. The difference between means is significant.

TABLE I

LENGTH OF TIBIA (in millimetres)	NORMAL	PARASITISED
2.10	0	0
2.15	0	4
2.20	0	4
2.25	1	4
2.30	6	4
2.35	5	11
2.40	5	8
2.45	10	9
2.50	6	4
2.55	9	2
2.60	7	0
2.65	0	0
2.70	1	0
MEANS	$\overline{X} = 2.463$	$\overline{X}_1 = 2.356$
$N = 98$	$t =$ approx. 4.7	$P < 0.001$

TABLE II

LENGTH OF OVIPOSITOR (in millimetres)	NORMAL	PARASITISED
1.2	0	4
1.3	0	6
1.4	0	5
1.5	0	7
1.6	11	0
1.7	13	2
MEANS	$\overline{X} = 1.654$	$\overline{X}_1 = 1.396$
$N = 46$	$t = 3.50$	$P < 0.001$

4. Cicadula quadrinotata (Fab.)

On 1st June 1948, nymphs and a few adults of this Jassid were collected from grasses at Silwood Park (Ascot). The adults and nymphs are active and quickly drop from the plants when slightly disturbed.

Host plant

Cicadula quadrinotata (Fab.) was only found in places where *Dactylis glomerata* occurred. Consequently, a preliminary test was made to confirm this association. About 500 nymphs and adults were kept in a cage con-

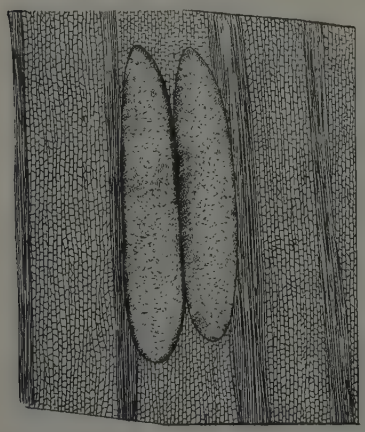
taining *D. glomerata* plants and other grasses collected from the habitat of *C. quadrinotata* (Fab.). The insects were continually watched for several days and it appeared certain that normally they feed on *D. glomerata* only.

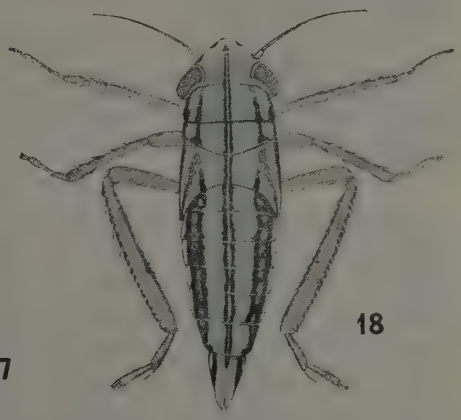
Rearing methods

The specimen tube with cotton wool and filter paper was used in rearing the nymphs and appeared to be most satisfactory. This method could not be applied for rearing the adults because their elytra stuck to the moist sides of the tube and the adults died. Consequently, they had to be kept in a small cellulose cage 5 × 9 inches fixed to a plant of *D. glomerata.*

Copulation

The newly emerged adults started copulation after 2 to 4 days. On 10th June 1948, five newly emerged couples were kept, each pair in a glass pot with cut pieces of *D. glomerata* leaves. Three pairs were found in copulation on 12th, one on 13th, and one on 14th June.





Cicadula quadrinotata (Fab.)

Fig. 17: Eggs in leaf-spathe of *Dactylis glomerata,* × 52. — Fig. 18: Nymph, × 12.5.

A copulated pair was kept in a refrigerator at 1° C. for 5 minutes and then treated with hydrogen cyanide. This was successful in killing the insects in situ for investigation.

Oviposition

On 24th June, 10 couples of *C. quadrinotata* (Fab.) were kept in glass pots provided with cut pieces of leaves taken from blade. These cuttings were examined daily, but no eggs were found for about a fortnight. The plants on which a stock of adults were kept revealed the egg-site which is

to be found in the cuticle of the leaf-spathe (fig. 17). Eggs are laid parallel to the leaf veins, and are often found singly, though a few are found in pairs. Some of the eggs produce a slight swelling. There is no external indication of the egg-slits made by the ovipositor. When the embryo is full grown its bright red eyes show through the lower or upper thin epidermis. A single female lays about 50 eggs.

Incubation period

On 10th June, 12 eggs of *C. quadrinotata* (Fab.) were laid. Six eggs hatched on 19th, 4 on 20th, and 2 on 21st July, i.e. 9-11, mean 9.7 days.

Leaves containing eggs were kept in direct contact with wet filter paper at a temperature of 13 to 25° C. The filter paper had to be changed during the incubation period when any fungus grew. Some eggs were also removed from inside the leaves and laid on the wet filter paper. This last trial was promising, largely avoiding the fugus infection which usually damages the eggs. Some other eggs left in the growing leaves hatched out without any trouble from fungus.

The egg

Colour whitish; narrow, elyptical and tapered slightly towards the operculum; length 1.1 mm. The egg (fig. 17) before hatching shows the bright red eyes of the embryo through the chorion.

Variation in colour pattern of nymphs

A range of colour pattern occurs in this species from a general light yellow to a nearly black colour. On 24th June 1948, 30 nymphs of the last instar (fig. 18) were collected at random and classified according to three colour grades, light yellow, dark and black. These grades were separated into females and males. The light yellow nymphs amounted to 10 (77%) females and 3 (23%) males, the dark nymphs to 6 (66.7%) females and 3 (33.3%) males, and the black nymphs to 2 (25%) females and 6 (75%) males. From the above figures it appears that the percentage of the males to the female in each group increases towards the darker grades.

Seasonal occurrence

In the second week of May 1948, nymphs of *C. quadrinotata* (Fab.) were available. In the second week of June the adults emerged but some nymphs were still found. On 11th July five nymphs were collected after a long search. The adults were actively laying eggs a few days after emergence. The eggs laid in the middle of June started to hatch out from the third week of July. In the first week of September nymphs were ony found. This suggests that *C. quadrinotata* (Fab.) hibernates as a nymph.

Parasites

Pipunculus haemorrhoidalis (Zett.)

On 26th June 1948, a parasitised nymph of *C. quadrinotata* (Fab.) was collected. The parasitic larva pupated on 27th and its adult emerged on 22nd July 1948. It was kindly identified by O. W. Richards.

Dryinidae

On 28th June 1948, a male nymph of *C. quadrinotata* (Fab.) was found with a Dryinid sac, but unfortunately the adult parasite failed to emerge.

On 30th June 1948, a nymph of *C. quadrinotata* was found with a Dryinid sac and at the same time parasitised with a Pipunculid.

5. Graphocephala coccinea (Forst.)

This Tettigoniellid leaf-hopper is a common North American species which occurs throughout the eastern United States and extends into Canada. It was first recorded in England in 1936, though the labourers in the *Rhododendron* gardens at Windlesham say that it first appeared there in 1931 or 1932. It is also reported from the following localities: Woking (1936), Oxshott (1937), Slough and Langley Park (Buckinghamshire) (1942), Wimbledon (1944), Richmond Park (1945) and the Haslemere district close to the Hampshire and Sussex borders (1947).

In the second week of July 1947, this beautiful bright coloured leaf-hopper was observed in vast numbers on *Rhododendron* bushes at Silwood Park. 50 females and the same number of males were confined in a big muslin cage, but unfortunately after living on *Rhododendron* for a week, 70 individuals died and no eggs were found. Ten days later 25 more died, and the rest perished within the next two weeks, without having laid any egg. On 15th July a fresh lot of 250 adults was confined in 25 cellulose tubes fixed to a *Rhododendron* plant in the field and distributed as 5 females and 5 males in each tube. The tubes were examined on 23rd November. 15 females and 15 males only were still alive, and no eggs were found. The females were dissected and found with fully developed eggs (fig. 19). The failure of oviposition was settled when the insect was provided of its hibernating egg-site consisting of growing plant bearing flower buds.

Hibernation

On 11th July 1947, three nymphs were collected from *Rhododendron* bushes and several nymphal exuvae were found fixed to the leaves. 200 adults were collected weekly from July to the middle of October. In the last week of November, only 7 females were found after a long search underneath

the bushes of *Rhododendron*. The identity of the hibernating stage remained uncertain.

Several other trials were made at the end of autumn 1947 and during the winter to find the hibernating eggs, but unfortunately only one egg was found in a *Rhododendron* leaf.

On 7th May 1948, nymphs were collected from the leaves of *Rhododendron* at the Imperial College Field Station, Silwood Park, Sunninghill, Berkshire. Similar nymphs were also found on weeds and grasses underneath the bushes.

A critical examination of several bushes revealed the site of the hibernating eggs. They were found inserted underneath the thin upper epidermis of the sepals in prominent swellings of the autumn flower buds of *Rhododendron* (fig. 20). Owing to the transparency of the epidermis and the yellow colour of the eggs, the swellings were yellowish in appearance. After the eggs had hatched out the swellings showed dark brown spots and the exuvae of the first nymphal stage protruded from the opening of the egg-slits.

It appears that the first stage nymphs moult as soon as they hatch out, when on their way out of the egg pockets. At the tip of each swelling a short dark line indicates the position of the wound caused by the ovipositing female.

The hibernating eggs are often found in a fan-like arrangement, 2 to 10 eggs being in each group. Such eggs, mostly radiating from the mid-line of the sepals, lie on the circumference of a circle with their axes pointing towards the centre. Other eggs are found singly. Some are partly or completely covered by the outermost sepals.

The hibernating eggs, before hatching out, are oval in shape, flattened, and tapered towards the operculum. They have a rather thin chorion and measure about 1.8 mm. in length.

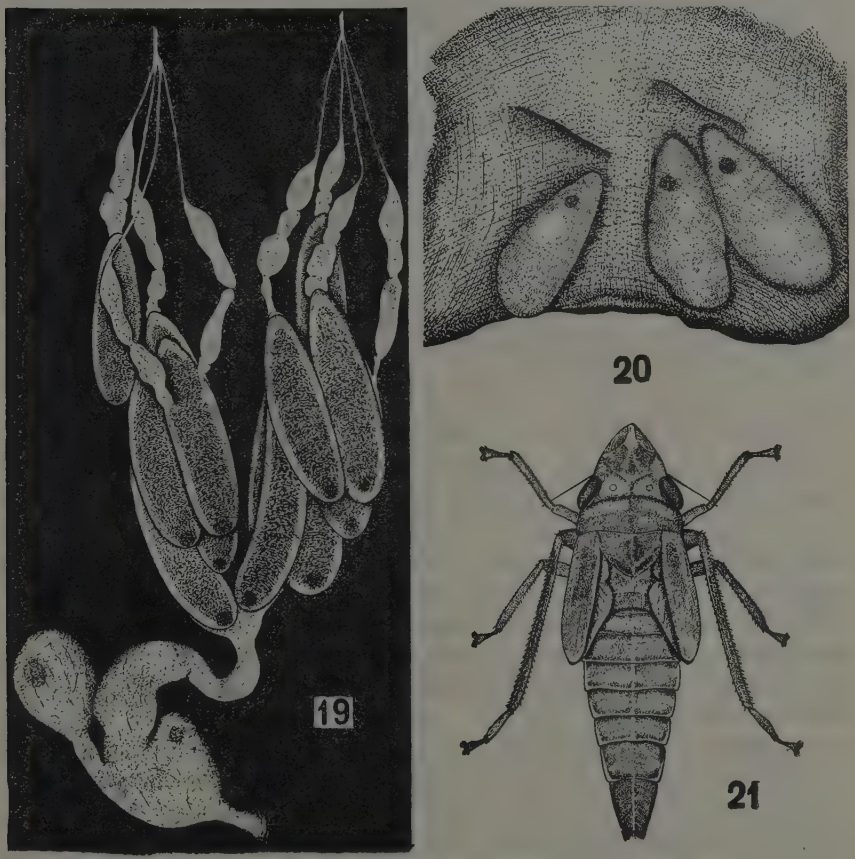
Host plants and feeding habits

Adults and nymphs of *Graphocephala coccinea* were collected from *Rhododendron* plants, though a few occurred on grass near these bushes. Some adults were also found on holly, ivy, *Viburnum tinus* (*laurustinus*), *Pteridium aquilinum*, *Rumex acetosa*, *Callistephus chinensis* Nees (Chinese Aster), *Robinia pseudacacia* L. (False *Acacia*), *Castanea sativa* L. (Sweet (Spanish) chestnut) and *Tilia sp.* (Lime).

On 20th May, an experiment was set up to investigate the possibility of rearing *Graphocephala coccinea* (Forst.) on the above mentioned plants (but the last four). A cellulose tube was fixed to a specimen of each, and about 10 nymphs were confined in each tube. In the first week of July, when the tubes were examined, all the nymphs were found alive and their

moulted skins were still fixed on the plants. This result shows the possibility of feeding these insects on any of the above plants.

Another experiment was made to indicate feeding preferences of the nymphs for any of these hosts. Nymphs were confined in a big muslin



Graphocephala coccinea (Forst.)

Fig. 19: Female reproductive organs, ×15. — Fig. 20: Eggs in a part of the sepal of *Rhododendron* flower-bud, ×15. — Fig. 21: Last nymphal instar, ×9.5.

cage containing potted *Rhododendron*, grass, *Rumex acetosa*, *Rumex acetosella* and *Hypochoeris radicata*. The nymphs fed mainly on the lower side of *Rhododendron* leaves and a very few on *Rumex acetosa*. None were seen to feed on grass, *Rumex acetosella* or *Hypochoeris radicata*.

On 7th May 1948, when the nymphs emerged, it was thought that they might possibly feed on grass until the new soft leaves of *Rhododendron* appeared. Consequently, an experiment was set up; some nymphs were fed on grass, some on old thick leaves of *Rhododendron* and others on soft ones. All the nymphs grew successfully fed in each case.

Finally, though *G. coccinea* (Forst.) is found mainly on *Rhododendron* in Britain at the moment, in the future it is probable that it will establish itself on other plants in large numbers as recorded in America.

Injury to plants

The injury caused by *G. coccinea* (Forst.) to *Rhododendron* leaves is inappreciable. It is surprising that no apparent damage could be noticed in spite of the vast number of nymphs and adults that swarm on some plants. However, the plant on which about 40 nymphs were reared from the 10th May to 6th July was examined. The upper leaves of the plant near the growing buds only showed noticeable damage. One of the leaves had 42 nymphal skins attached to its lower side. The leaf showed a yellow spotted appearance on its upper side, with a dark green thin stripe on either sides of the mid-rib.

Rearing

It was found that the method applied for rearing *Delphax fairmairei* Perris under laboratory conditions was unsatisfactory in the case of *G. coccinea* (Forst.). On 8th May 1948, 30 nymphs (second instar) were reared singly in 1 × 2 inches glass specimen tubes, each containing a piece of *Rhododendron* leaf, grass, and a leaf of *Rumex acetosa*. The leaves were changed daily. The duration of the second instar varied from 8 to 11 days. 7 nymphs moulted after 8 days, 13 after 9 days, 4 after 10 days, 2 after 11 days and 3 died. The duration of the third instar varied from 4 to 18 days and 14 nymphs died.

Figure 21 shows the last or fifth nymphal instar.

It was remarkable that the nymphs fed mostly on *Rumex acetosa* leaves which is not normally their favourite host. This tendency could be attributed to the leaves of *R. acetosa* being fleshy and containing a good amount of sap. The cut leaves of *Rhododendron* seem to contain much less sap and get dry more quickly than those of *Rumex acetosa*. Thus the nymphs might have preferred *R. acetosa* because they have the habit of fixing their mouth-parts and keeping on pumping the plant juice through one puncture for a considerable time.

Consequently, another method of rearing was tried, in which the nymphs were provided with growing plants.

On 10th May 1948, about 50 eggs of *G. coccinea* (Forst.) hatched out. Some of the nymphs were transferred to three cellulose tubes fixed to

leaves of a potted *Rhododendron* and the rest to the fairly big muslin cage described previously. The nymphs were successfully reared in both ways, and the adults emerged on 6th July 1948. They took 56 days from the hatching of the eggs to the emergence of the adults. These results were obtained from insects kept in an unheated conservatory. The temperature during this experiment varied from 13 to 25° C.

Seasonal occurrence and number of generations

The hibernating eggs of *G. coccinea* (Forst.) hatched out from the first week of May. Nymphs occurred during May, June and July. The adults reared under laboratory conditions emerged on 6th July 1948, but those in the field emerged on 20th July. They were collected from the third week of July until the middle of November, though 7 females were collected on the last week of November 1947 after a long search. The eggs were laid from the first week of September and kept in hibernation until the first week of May. From these observations *G. cocinea* (Forst.) must have one generation a year in Great Britain, and not two as stated by Osborn (1912).

The egg

The egg (fig. 20) is oval flattened and tapered towards the operculum, yellow in colour, and about 1.8 mm. long.

6. Tettigoniella viridis (Lind.)

This Tettigoniellid leaf-hopper was noticed in a damp place by a stream on the west side of the Imperial College Field Station.

The female is about 8.2 mms. long with greenish blue elytra extending to the apex of the abdomen. There are two black pentagonal spots on the crown, located between the two ocelli. A black spot is also found on the above margin of each antennal socket. The male is about 6.3 mms. long with the elytra of a navy blue colour. The elytra extend from about 1 mm. beyond the abdomen.

Host plants

Tettigoniella viridis (Linn.) feeds on *Holcus mollis* which grows vigorously in damp places, the favourite habitat of this insect.

Hibernation

In the sumer of 1947, several attempts were made to induce the females of *T. viridis* (Linn.) to lay their eggs in grass (*Holcus*) under laboratory conditions. Unfortunately no eggs were laid. Another trial was made by fixing a cellulose cylinder 8 × 12 inches to the soil in the part of the field where *T. viridis* occurrend amongst grass. Many holes were made in this cylinder to provide proper ventilation. It was also covered with a tin lid

having perforations in the centre. Some females and males were confined in this cage and all died after a considerable time. The grass of the cage was examined, and again no eggs were found.

Consequently, in the winter of 1948, it was thought that the eggs might have been laid in certain woody plants that exist in that spot. A considerable number of brambles, and four oak trees were examined without success.

On 13th May, stems of *Juncus effusus* found in the same spot as *T. viridis* (Linn.) were examined, and revealed the presence of the hibernating eggs.

Oviposition

The female makes long slits with its ovipositor in the stems of *Juncus effusus* where the eggs are laid. The egg-slits are 3.5 to 7.5 mms. long and contain 3 to 16 eggs in one row (fig. 22). All of the eggs are found beneath the scale from about 2.5 to 17.5 cms. above soil level, probably because this part of the stem remains green during winter while the upper part of the stem often dies off, and also because it is nearest to the soil and hence the eggs are kept in damp conditions.

The egg-slits are made parallel to the stem veins under the scale leaf, and are difficult to detect unless the scale is removed, though some show

Fig. 22: Eggs of *Tettigoniella viridis* (Linné) in stem fo *Juncus effusus* (longitudinal section in plant), ×12.

prominent swellings. Eggs are located at an acute angle to the plant surface about 0.3 mm. underneath the cuticle of the stem or right through the centre of the pith. Their presence can be detected as follows:

(1) A dark pinkish, thin straight line showing no indication of either a swelling or an opening.

(2) The same dark pinkish line having an opening in the stem with one margin of the slit being folded inwards.

(3) As in 2 but exhibiting a swelling, and the white ivory tips of the eggs (just before hatching) showing through the opening of the slit.

The egg

The egg (fig. 22) is about 1.7 mm. in length. Just before hatching it is yellow with two orange patches laterally, oval in shape with a swelling

in place of the embryo's head and tapered, with an ivory white apex. The dark brown eyes of the embryo show through the transparent chorion as a distinct dark spot on each side of the egg.

Rearing

As *Tettigoniella viridis* (Linn.) occurs in damp places, it was thought advisable to keep the eggs removed from inside the stem in direct contact with the wet filter paper in the pots.

On 13th May 1948, 30 eggs hatched under laboratory conditions. The nymphs were distributed singly in the pots and provided with cut pieces of *Holcus mollis*. Fifteen nymphs died after two days and the rest did not live more than two days longer. After two more trials, replacing the dead nymphs by newly emerged ones, the number of dead insects was still very high.

As leafhoppers tend to keep on sucking the sap of growing grass through one puncture for a considerable time, a certain amount of nymphs were bred on growing grass in pots covered by a $1 \times \frac{1}{2}$ inch glass tube. The nymphs kept alive for 24 days, when the grass ceased to keep healthy.

Another method was tried for rearing first stage nymphs. They were kept in a fairly big cellulose cage surrounding growing grass in a plant pot. The cage was examined every now and then, and as soon as the nymphs moulted they were transferred to another cage fixed to fresh growing grass; this was repeated with all stages. This method proved to be satisfactory, for the nymphs were reared successfully up to the adult stage. In spite of the success, the data obtained were insufficient owing to the late date at which this trial was started. By that time very few eggs were available and consequently very few nymphs were obtained.

Seasonal occurrence and number of generations

Eggs of *T. viridis* (Linn.) were found on 13th May 1948 in the stems of *Juncus effusus*. A few of them had already hatched by that time. Other eggs, very few, were found in the first week of June in another spot. As to the adults, they appeared in the field in the first week of July, and became very scarce in the fourth week of September. Egg-laying occurred in the fourth week of August (24th) and the eggs hibernated until the first week of May. Consequently, *T. viridis* (Linn.) has one generation per annum.

Parasites

Anagrus incarnatus Hal.

Some eggs of *Tettigoniella viridis* (Linn.) collected on 13th May 1948, were found parasitised by *Anagrus incarnatus* Hal. (Hymenoptera: Mymar-

idae). Each egg contained from 3 to 11 parasites, while in *Delphax fairmairei* Perris there is never more than one parasite per egg.

On 1st June 1948, 80 egg-slits were examined. They contained 979 eggs, thus an average of 12.2 per slit. 46 eggs (4.7%) were found alive, 318 (32.5%) were already hatched, 38 (3.9%) were found dead, 122 (12.5%) were parasitised. 455 eggs (46.5%) were killed through a mould (*Acrostalagnus* spec.), kindly identified by Mr. R. K. S. Wood, of the Botany Department, Imperial College, England.

7. Cicadella notata (Curt.)

This leaf-hopper belongs to the family Typhlocybidae and is characterised by its pronotum bearing five short longitudinal lines (a median at the centre of the front margin, one on either side at the posterior angles, and one on each side between the median line and the postero-lateral ones), the abdominal sternites which are yellow in both sexes with the exception of the eighth sternite (before the sub-genital plate) black in the male, the pygophor of the female, and the outer valves of the ovipositor, are black.

Cicadella notata (Curt.) occurs amongst grasses, and almost always in spots where *Hypochoeris radicata* grows.

The adults exhibit the same general habits as do most Jassids, but the nymphs differ in some respects. Unlike the nymphs of Jassids, those of *C. notata* (Curt.) are inactive and show a tendency to settle on the leaves unless they are disturbed. They do not hop and prefer the shaded side of the leaf.

Symptoms of infestation

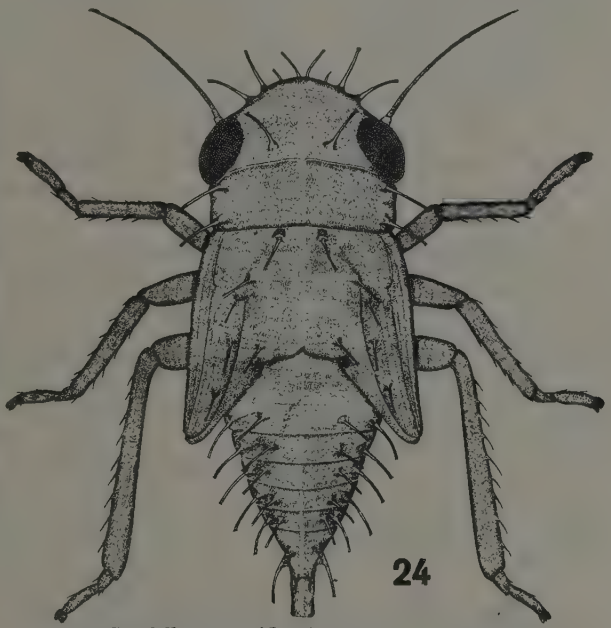
The infested leaves of *Hypochoeris radicata* exhibit white mottled patches with brown and yellow scorched areas. 10 adults were fed on a healthy plant and produced the same symptoms of infestation as had been found in the field. The flower stalk fed on by this leaf-hopper exhibited the same diseased appearance.

Oviposition

Six females were kept singly after copulation, but unfortunately the exact date of oviposition was not known because of the difficulty f finding the eggs inside the tissues of the plant. The eggs (fig. 23) are rather small (400 μ long), whitish in colour, more or less of the same colour as the tissues in which they are inserted (the thick fleshy midrib of the leaves which is prominent on the lower side of the leaf, and also in the flower stalk), and tapered slightly towards the operculum. They are often laid horizontally in the midrib or perpendicularly into its surface. Some of them were found underneath the epidermis of the midrib which exhibited a slight swelling. Eggs found in the flower stalk were either underneath the outer epidermis,

which shows a slight swelling, or inserted inside the tissues without any sign of their presence. In the older flower stalks, which have a cavity inside, a few eggs were found just covered by the innermost thin tissue, showing a swelling towards the inner cavity. The eggs are laid either singly or in pairs.

23



24

Cicadella notata (Curt.)

Fig. 23: Eggs in flower-stalk of *Hypochœris radicata*, ×80. — Fig. 24: Fifth or last nymphal instar, ×22.

There is no indication of the oviposition slit where the eggs are laid. This is probably due to the nature of this plant, which is juicy, the wounds healing quickly without leaving any trace.

Incubation

On 26th June 1948, some females of *Cicadella notata* (Curt.) were confined in a cellulose tube round a flower stalk of *Hypochoeris*. They laid few eggs. The stalk containing the eggs was cut and kept under observation. The eggs hatched on the 20th July, i.e. after 25 to 27 days under laboratory conditions, with a temperature of 13 to 25° C.

Copulation

Some adults emerged on 25th June 1948 were found in copulation after three days and others after four days.

Seasonal occurrence, hibernation and number of generations

C. notata (Curt.) nymphs (fig. 24) were difficult to find in the first half of May 1948, but a few were collected in the third week. In the last week some nymphs of the last instar (fifth) were collected.

The adults appeared in the first week of June. Those which emerged in the third week started to lay eggs after a few days. The eggs which were laid on 26th June hatched on 20th July. The duration of the nymphal instars is about 25 days. The adults emerged in the last week of July and the first week of August. Some of them started laying eggs in the beginning of August and adults emerged in the second week of September. These observations were made from laboratory rearing, but were confirmed in the field. Collections made on 28th September 1947 yielded 30 adult females, 24 adult males, and 2 nymphs. A search for adults and nymphs during the winter was unsuccessful. Hence it seems that *C. notata* (Curt.) hibernates in the egg-stage, and has three generations per annum, the third occurring in late autumn. This does not quite agree with Ribaut (1936) who states that usually there are two generations in Typhlocybidae, the second one occurring before winter.

Duration of the nymphal instars

C. notata (Curt.) has 5 nymphal instars, the combined duration of which is about 25 days under laboratory conditions with a temperature of 13 to 24° C.

On 5th July 1948, 10 eggs hatched and the nymphs were reared singly. Though some nymphs varied in the duration of their instars, yet the adults emerged on nearly the same date (8 on 30th, and 2 on 31st July).

The duration of the nymphal instars summarises as follows: first instar, eight nymphs six days, two seven, mean 6.2 days; second instar, two nymphs four days, sever five, one six, mean 4.9 days; third instar, two nymphs two days, six three, two four, mean 3 days; fourth instar, four nymphs six days, six seven, mean 6.6 days; and fifth instar, eight nymphs four days, two five, mean 4.2 days.

Parasites

Chalarus spurius (Fallen)

Chalarus spurius (Fallen) (Diptera: Pipunculidae), identified by O. W. Richards, emerged on 13th July 1948 from a parasitised nymph of *C. notata* (Curt.) collected on 11th June 1948. The full grown parasitic larva migrated from its host on 13th June and pupated next day.

IV. SUMMARY

(1) Several methods using different types of cellulose tubes and cages were satisfactory for rearing *Jassids* and *Delphacids*, providing proper ventilation, reasonable humidity and a supply of fresh plants.

(2) The *Delphacids* dealt with were *Criomorphus pteridis* (Boh.) and *Delphax fairmairei* Perris Their life-history and bionomics are recorded. *D. fairmairei* hibernates as eggs in aerial stems and runners, and in the leaf stalk of blackberry in either egg-sacs or egg-slits. Eggs were found parasitised by *Anagrus incarnatus* (Hal.).

(3) A few Pipunculidae (Diptera) were found in diapause as eggs or larvae in the hibernating nymphs of *C. pteridis*.

(4) The *Jassids* dealt with are : *Cicadula sulphurella* (Zett.), *Cicadula quadrinotata* (Fab.), *Graphocephala coccinea* (Forst.), *Tettigoniella viridis* (Linn.), and *Cicadella notata* (Curt.). Their life-history and parasites are given.

(5) The oviposition site of *C. quadrinotata* was found to be the leaf spathe of *Dactylis glomerata*.

(6) The hibernating eggs of *G. coccinea* were found beneath the sepals of the dormant flower buds of *Rhododendron*. The nymphs were successfully reared on several hosts. *G. coccinea* has one generation per year in Britain.

(7) The hibernating eggs of *Tettigoniella viridis* were found in the stems of *Juncus effusus*. The eggs are parasitised by *Anagrus incarnatus* Hal. From 3 to 11 parasites were found in single eggs. The eggs are also attacked by *Acrostalagnus* spec., a white fungus.

(8) *Cicadella notata* was found to feed on *Hypochoeris radicata*. The eggs are laid in the midrib of the leaves and in the flower stalk. The nymphs and adults are parasitised by *Chalarus spurius* (Pipunculidae).

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Further studies in Proctotrupoidea:

1. THE GENUS PHAENOPRIA ASHM.,

2. THE GENUS MONELATA FOERST.,

AND

3. REMARKS ON DIAPRIA LATR. AND ALLIED GENERA (1)

[Hymenoptera]

by Prof. Dr. H. Priesner

1. GENUS PHAENOPRIA ASHM.

Phaenopria major spec. nov.

Female: Black, much shining; antennae dark, joints 2-9 usually dark red or blackish-red, femora and clubs of tibiae dark, trochanters and slender portion of tibiae fulvous, terminal tarsal joint or also some of the preceeding joints darkened. Fore wings with marginalis dark; an indistinct lineola (2) present.

Head (330 μ) scarcely narrower than thorax (363 μ), roundedly narrowed towards base. Scape (length 277-295 μ) about as long as the five following joints combined, stout, somewhat curved; joint 2 little convex laterally, length 87 (width 44) μ, somewhat longer than 3 (70 μ), joints 4-7 very slightly longer than broad, 8 about as long as broad, 9 scarcely transverse, joints 10 to 12 forming a well separated club, 10 being scarcely, 11 slightly transverse, 10 and 11 combined about 120 μ long, joint 12 twice as long as 11 (120 μ). Thorax with greyish fur in front. Scutellum without any trace of a foveola, basally with hardly noticeable arched depression, mesonotum separated from scutellum by a fine line; scutellum with sharp carina

(1) cf. Priesner, *Bull. Soc. Fouad I d'Entom.*, XXXIII, 1940, pp. 71-81.

(2) The term « lineola » is being introduced for the slight basal infuscation of the fore wing, which Kieffer mentions as « wenig deutliche gelbe Querlinie », and which is supposed to be the rudimemt of the basal vein.

in posterior half or third. Propodeum medianly sharply carinated, keel rectangular in lateral view, the declivous portion of the keel only scarcely concave; sides of propodeum with long adpressed hairs that are not densely arranged or fur-like as they are on the thorax. Petiolus, in dorsal aspect, somewhat broader than long, pilosity similar to that of the propodeum. Abdomen sharply pointed, length from segment II 813-880 μ, segment II alone about 554 μ long, all segments smooth, shining, scantily pilose at apex. Fore wings 520-590 μ broad, fringe-hairs moderately long, 120-130 μ. Margin of wing in front of marginalis with 7-9 bristles, the basal of which being more widely separated than the distal ones. Hind tibiae at apex with a fringe of bristles the innermost of which being longer than the exterior ones, the longest being about 48 μ long; exteriorly, the hind tibiae with terminal, short, stout spur; length of hind tibiae 450-466, length of hind tarsi 415 μ, segments of hind tarsi : 136, 80, 68, 52 and 88 μ. — Total body length: 1.6-1.7 mm.

Habitat : Females, Austria (Linz, Marchtrenk, Michldorf, April and July to November).

Male : Black, strongly shining, petiole reddish (at least at sides), legs (inclusive of coxae) dull fulvous, clubs of femora scarcely, clubs of tibiae slightly shaded, as well as is the terminal tarsal joint. Antennae black, scape and joint 2 dull fulvous, the former slightly shaded dorsally, bases (narrowly) of the remaining antennal joints more or less dark reddish.

Scape length about 277, joints 2-5 : 80(42), 138(43), 120(52) and 109 μ long (broad), respectively; joint 7 about 105 μ long; joint 2 elongate-oval, 3 much longer, widened towards apex, slightly narrowed about middle, 4 bluntly angularly widened, terminal antennal joint about 120 μ long, elongate-oval, pointed. The joints are irregularly set with fine, curved hairs the length of which exceeding partly the width of the segments. Head somewhat spherical, with a well developed greyish fur at the temples, and thorax with such a fur in front, laterally. Thorax and scutellum sculptured as in the female. Abdomen, length from segment II 623-640 μ. Width of wings about 536 μ, fringe at *apical* margin about 95 μ long, at hind margin longer.

Described after a unique specimen (Austria, Linz, IX) that most likely belongs to the female described above.

This species is the largest one known to me and comes closest to *cameroni* Kieff. for which I had originally taken it. Kieffer expressly states (« Tierreich », 1916, *Diapriidae*, p. 55) that in his species the antennal joints 4-9 are globular. In *major*, joint 4 is distinctly somewhat longer than broad and its sides are straight, somewhat widened towards apex, not rounded.

Phaenopria minor spec. nov.

Female : Agreeing with *Ph. major* in many characters, it differs by its smaller size, the somewhat narrower wings, somewhat shorter antennae in which joint 4 is scarcely elongate, joint 3 distinctly shorter than 2, club 230 μ long. The wings have a breadth of 433, the fringe hairs are about of the same length as in *major*, 86-95 μ. The antennal joints 2-12 (combined, under low magnification) 484-520 μ long. The antennal joints measure (taken from a specimen of medium size, in microscopic preparation) : 225-242, 72, 56-60, 34-36, 32, 32, 34, 28(34), 32(40), 52(58), 56(67), 116(68) μ (the pedicels are retracted into each preceeding segment and therefore not measured). Length of hind tibiae 310-330, of hind tarsi 330 μ; segments of hind tarsi: 112, 68, 56, 44 and 64-68 μ. In the holotype, the head has a breadth of 277, the thorax of 288 μ, the abdomen from segment II to apex is 690-735 μ long. The hind tibiae are similar to those of *major* in their pilosity, apically they bear, as in *major*, besides the bristles, two small pale plates that are fringed at apex.

Male : Antennae moniliform, similar to those of *major*, but shorter, measuring from segment 2 to 14 : 1.125-1.14 mm. Joint 3 about 99-112, joint 4 : 47-52 μ broad; it is widened exteriorly behind middle, somewhat angular, and bears a small spine. The wings have a width of 450-520 μ. The pilosity of the antennae is about the same as in *major*.

Habitat : This species is not rare in forests, the female from April to November, in Central Europe (type specimens from Upper and Lower Austria, Linz, Michldorf. D.-Altenburg, Vienna), the males from July to September.

This species may well be identical with Kieffer's *Ph. cameroni*, though it does not agree with the description given by Kieffer (l.c.), as the scape is longer than the four following joints combined, 3 and 4 are somewhat longer than broad, and therefore joint 4 is not globular. In any case, if one of the two species just described is the same as *cameroni*, *minor* is more likely to be identical with it than *major*.

Phaenopria simulatrix spec. nov.

Female : Differing from *major* by the much smaller size and the shorter and stouter antennae, as well as the relatively much longer fringe hairs of the wings, from *minor* by the finer flagellum, in which joints 8 and 9 and the first club joint (joint 10) are not distinctly transverse. The wings are only 345-380 μ broad, the fringe hairs measure 87-120 μ at apex of wing. Joints 2-12 of the antennae are combined 484-520 μ long, joint 12 not exceeding 106 μ. The flagellar joints (antennal joints 3-9) are somewhat paler reddish-brown than in *minor*.

In the holotype the head and thorax have a width of 250 μ, the abdomen from segment II to apex is 588-606 μ long. From a microscopic preparation the antennal joints show the following exact measurements: 208, 64 (pedicel included 76), 52, 36, 28, 28, 32, 28(30), 32(36), 44-52(52), 48-52(56), 108(60) μ. (widths between brackets). The hind tibiae are of the same configuration as in the foregoing species, but (as well as the tarsi) 277 μ long; the tarsal joints measure 88, 56, 48, 38 and 60 μ.

Male: Also the male is very similar to that of *minor*, but the antennae are shorter, joint 13 being of the same width but shorter, joints 3 and 4 do not exceed 86 μ in any of the four specimens of my collection. Joints 2-14 measure about 950 μ, joints 3 and 4 each 78-86 μ, width of joint 4 about 38 μ, shape and spine as in *minor*. Width of wing 363 μ.

Habitat: This species is also not rare in Central Europe, the type specimens originating from Austria (Marchtrenk, Linz, Sarleinsbach), and were taken in rather dry forests from June to November, the males from August to September. A series of specimens (6 females and 1 male) of a certainly quite common form from Egypt (Cairo, Meadi, Fayed, swept from Gramineae and taken from detritus of an irrigation canal), I cannot distinguish from the European *simulatrix*. This insect must have a very wide distribution.

Phaenopria aegyptorum spec. nov.

Female: Black, mouth, petiolus and sometimes prothorax reddish, legs (inclusive of coxae) fulvous, clubs of femora and tibiae scarcely shaded, tarsal joint 5 slightly darkened; scape pale yellow in basal half, brown in distal half, joints 2-9 of antennae dull fulvous, club brownish or dark; subcosta and marginalis fulvous.

Head about as broad as thorax, somewhat longer than broad, roundedly narrowed towards base. Scape well as long as the four following joints united, thin in basal half, curved; joint 2 somewhat longer than 3, 4 considerably shorter than 3, 4-9 little differing in length from one another, 9 little broader than 8, 10 and 11 longer, much broader, subequal in length, but differing in width, 11 being much broader than 10, *joint 12 long*, more than twice as long as 11; club distinctly three segmented. Mesothorax slightly convex in front, together with base of scutellum somewhat flattened behind; scutellum without a trace of a foveola or incised longitudinal line (cf. *Ceratopria* spp.), somewhat raised longitudinally posteriorly, finely marginated at the sides. Keel of propodeum, even in front, only little elevated, not triangular; propodeum emarginated behind, margin reddish. Petiolus somewhat longer than broad, thick in front (in lateral aspect), convex above, posteriorly one-half as broad as in front, dorsally and laterally pilose. Tergite II of abdomen somewhat produced over the petiole at base. Wings

surpassing tip of abdomen, moderately broad, lineola wanting; fringe moderately long, longest fringe hairs on hind margin about one-fourth or less of greatest width of wing. Abdomen narrowly fusiform. Hind tibiae, as usual, thickened in posterior third, hind tarsi about as long as hind tibiae, joint 1 as long as 2 and 3 combined, joints with some stout bristles at tip within, and joints 1-3 with a series of stout bristles at inner margin.

Measurements (in μ) : Head, length 310, width 277, hight 286; eyes' diameter 120; antennae, length 917; joints, lengths (breadths) without pedicels 277(28), 79(36), 61-63(28), 39(28), 39(28), 36(31), 39-41(32), 36(32), 39(36), 63(55), 63(65), 138(70). Thorax, length 484-520, width 277. Wings, length 1210-1228, width 433, costa + marginalis 330, fringe 70. Petiolus, length dorsally 120, laterally 173, width 60; segment II, length 450, width 294-303; III, length 52; IV, 43; V, 52; total length of abdomen 693-760. Hind tibiae, length 346-380; hind tarsi, length 346-372; joints, lengths 126, 70-75, 53-59, 47, 70-80. — Total body length : 1.57 mm.

Male : Unknown.

Habitat : Meadi, Egypt, 5.v. and 6.xi.1933, from the detritus of an irrigation canal.

Phaenopria aegyptorum differs from *major* by its smaller size, paler antennae and legs, longer terminal joints of the antennae, the not transverse joint 10, the smaller joint 3, the more distinctly clubbed scape, the narrower wings and shorter fringe hairs; *Ph. minor* has more strongly transverse joints 10 and 11, somewhat shorter joint 12, darker antennae and legs and denser pilosity of the transverse, dark petiolus; *Ph. simulatrix* is distinguished by the darker colour, the short petiole and much shorter antennae. Most closely allied to our new species seems to be Kieffer's *Ph. cavernarum* (cf. l.c., p.58), as Kieffer in his description of this East African species particularly points to the trichomes on the club joints of the antennae which are present in our species, too. Such trichomes, however, are a generic character, as they are present in *major* and *minor*, too, in fact in all species examined by the author, and are perhaps differing only in number, length and position. In *cavernarum*, the petiolus is, though red as in our species, *transverse*, and the carina on the propodeum is sharply raised; *cavernarum* Kieff. must, therefore, be a different species.

Phaenopria revelata spec. nov.

Female : Colour and general characters as in *simulatrix*, the legs somewhat paler, trochanters, basal half of tibiae and the four basal tarsal joints yellow. Narrower species.

Head and thorax, width 200 μ; scutellum at base with a very shallow arched impression that joins the lateral raised margins of the scutellum, as

this is the case in *simulatrix*. Width of abdomen only 200 μ, length from segment II : 450-467 μ, apex of abdomen sharply pointed. Wings, length 830-850 μ, length from base of wing to end of marginalis 240-260 μ, width of wing only 260 μ. Fringe hairs, length at apex of wing 70-87, longest fringe hairs at hind margin 120 μ long. Costa in front of marginalis with 5-6 bristles of which the distal ones are a little more densely set than the two basal ones. Petiole broader than long, in dorsal aspect. Carina of propodeum about rectangular, in lateral view; posteriorly, the propodeum is rounded at sides, not pointed. Antennae, length of segments 2-12 combined. 415-433 μ. Lengths (widths) of antennal joints : 190, 60(30) (with pedicel 72 long), 40(22), 30(22), 24(22), 24(23), 28(24), 24(26), 26(28-30), 40-42(41), 40-42(44), 88(48) μ. Hind tarsi longer than hind tibiae, the former 225, the latter 260 μ long; tarsal joints : 88, 48, 38-40, 30, 48-50 μ long. Bristles of tibiae and tarsi as in *simulatrix*. — Total body length : 1.16-1.18 mm.

Habitat : Two specimens, Meadi, Egypt, 15.v.1936 (leg. H. Priesner).

This species comes, owing to the long fringe hairs, rather close to *Ph. minima* Masi (Italy). Masi notes that in *minima* the length of antennal joint 2 is to its breadth as 5 : 3, in *revelata*, however, this ratio is 5 : 2.5 (or, if we measure the pedicel of segment 2: 5 : 2 only); joint 3 is only little shorter than 2, while it is much shorter (40 : 60 μ) in *revelata*; joint 7 of *minima* is said to be square, in *revelata* it is a little longer than broad; joint 9 of *minima* is somewhat broader than 2, in *revelata* it is as broad as 2; the club (joints 10-12) are 0.78 of the scape, in *revelata* these joints combined are 0.92 of the scape. The specific difference of the two species can definitely only be proved, however, if a larger number of the two forms will be available.

Phaenopria atomaria spec. nov.

Female : Similar to *revelata* in many respects, colour about the same. Head width about 180, length 190 μ. Scape of antennae curved, slightly constricted before apex, joint 2 strongly convex at sides, a little broader than scape, yet joint 7 in one direction somewhat broader than long, joints 8 and 9 distinctly transverse. Measurements of antennal joints (from microscopic preparation) : 130(28), 48(30) inclusive of pedicel 60, 32(20), ?, ?, 20(20), 20(22), 20(24), 22(28), 32-36(40), 36-38(46), 80(48) μ; joints 2-12 combined 330 μ long. Thorax similar to that of other species but only 172-176 μ broad. Propodeum roundedly excavated at posterior margin, hind angles sharply pointed. The thick, dorsally visible portion of the petiole 48-52 μ long, 60 μ broad, set with long hairs. Abdomen,

length from segment II to apex 380-400 μ, width of segment II 190 μ. Wings narrow, length 623-640, width 190 μ, length from base to apex of marginalis 208 μ; length of fringe hairs at apex of wing 87-95, length of longest fringe hairs at posterior margin 120 μ long; base of fore wing with 6 bristles, the distals of which are more densely inserted than the basal ones. Hind tibiae with short exterior spur, with short bristles at apex within, and having apparently the two small plates below not fringed; joints 1-3 of tarsi with long and rather stout bristles below. Hind tibiae, length 188, hind tarsi 192, tarsal joints 56-60, 40, 28, 24 and 40-42 μ long. Hind coxae as long as width of petiole. — Total body length : 0.93-0.95 mm.

Habitat : Egypt, Meadi, 19.v.1933, 1 female, leg. H. Priesner.

This form differs, no doubt specifically, from *Ph. revelata* by its narrower wings, though having fringe hairs of about the same length, and the distinctly more strongly transverse antennal joints 9-11.

Key to the palaearctic species of Phaenopria

Females

1 (2) Legs fulvous. Scape in basal half nearly only half as wide as in club-shaped distal half; joint 9 somewhat elongate. Petiole somewhat elongate, more or less reddish..... **aegyptorum spec. nov.**

2 (1) Legs not uniformly yellowish-red, femora and clubs of tibiae darkened. Scape not as indicated above.

3 (4) Petiole somewhat elongate. Antennal joints 10 and 11 scarcely transverse, 12 nearly twice as long as 11. Scutellum in front without the trace of a suture between it and mesonotum. Wings with lineola. Metapleurae with fur. Length 1.2 mm..... **fuscicornis Kieff.**

4 (3) Petiole as long as broad or transverse.

5(10) Longest fringe hairs of fore wing measuring about one-half the width of the wing. Wings narrow.

6 (7) Antennal 3 somewhat shorter than 2; ratio of length to width of joint 2 is about 5 : 3; joint 9 somewhat broader than 2. Petiole as long as broad. Joints 10-12 combined are 0.78 of length of scape. Body length 1-1.25 mm..... **minima Masi**

7 (6) Antennal 3 much shorter than 2; joint 2 having ratio of length to width, 5 : 2-2.25. Joints 10-12 combined 0.88-0.92 of length of scape. Joint 9 about as broad as 2.

8 (9) Antennal 2 very short, about 50 μ long, 30 μ broad. Joints 9-11 distinctly transverse. Wings about 190 μ broad..... ..... **atomaria spec. nov.**

9 (8) Antennal 2 more elongate, about 60 μ long, 30 μ broad. Joints 9-11 very slightly transverse. Wings about 260-280 μ broad..... ..... **revelata spec. nov.**

10 (5) Fringe hairs shorter.

11(12) Antennal 12 somewhat longer than 11. Scutellum with the trace of an arched impression. Wings without lineola..... **subimpressa Kieff.**

12(11) Antennal 12 much longer than 11. Scutellum without conspicuous impression at base.

13(14) Antennal 2 top-shaped, somewhat elongate, 3 little elongate, 4-9 globular, 10 and 11 scarcely transverse, 12 nearly twice 11. Antennae black. Wings with lineola. Metathorax with fine hairs, propleurae with fur. Length 1.5 mm. ..... **cameroni K'eff.**

14(13) Antennal 4 not globular.

15(16) Costa in front of marginalis with only five bristles which are about equidistant ..... **longiclava Masi**

16(15) Costa in front of stigma with at least 7 bristles the basal of which are more widely separated from one another than the distal ones.

17(18) Larger, 1.6-1.7 mm long. Antennal joint 3 only little shorter than the laterally little convex joint 2; joint 9 not or scarcely transverse. Lineola slightly indicated. Width of wings 0.52-0.59 mm. Length of fringe hairs 120-130 μ. Length of antennal 12: 120-130 μ. .... **major spec. nov.**

18(17) Smaller species. Width of fore wing at most 467 μ. Antennal joint 12 at most 113 μ long. Antennal 3 distinctly shorter than the laterally more strongly convex joint 2.

19(20) Flagellum thinner, joint 8-10 scarcely transverse. Joints 2-9 dull reddish. Width of wings 346-380 μ, fringe length 87-120 μ. Antennal 12, length about 105 μ..... **simulatrix spec. nov.**

20(19) Flagellum stouter, joints 8-10 at least in one direction transverse. Width of wing 398-467 μ. Fringe, length 105-130 μ. Antennal 12, length 110-114 μ..... **minor spec. nov.**

2. GENUS MONELATA FÖRST.

Monelata clavigera spec. nov.

Female: Black, shining, sides of thorax sometimes somewhat reddish, and also sometimes base of abdomen paler, petiole and apex of propodeum dull yellowish to fulvous, legs (inclusive of coxae) yellow, terminal tarsal joint darkened. Antennal joints 1-12 dull fulvous, scape palest, club (joint 13) wholly dark. Costa and marginalis yellowish.

Head from eyes towards base narrowed, sides straight, with a more conspicuous curved bristle in front, between eyes and base of antennae.

Head, width 255, thorax width 242 μ. Scape curved, about 43 μ broad before apex, 260 μ long, about as long as the six following joints combined; joint 2 (measured from extreme base to apex) 87 μ long, 35 μ broad, joint 3 only 52 μ long, 23 μ broad, 4 scarcely longish, penultimate joints somewhat thickened so that joint 10 is about as broad as joint 2, joint 11 broader, 43 μ, joint 12 about 52 μ long, 59-61 μ broad, club joint (13th) 194-196 μ long, 87-95 μ broad. Thorax with fur at fore angles, temples without fur. Scutellum separated from mesonotum, as normal, by a very fine transverse suture, having at the base an indistinct transverse, arched impression which joins the lateral margin and apical line of the scutellum. Wings narrow, length about 1195, width 398-433 μ; fringe of apical margin 86-95, of posterior margin about 105 μ; wings, length from base to apex of marginalis 433 μ. Sides of propodeum with yellowish, adpressed pilosity, carina of propodeum yellowish transparent, forming an obtuse angle, in lateral aspect. Petiole short, thick, densely pilose, posterior margin with longer, darker hairs, the latter surpassing the elevated base of segment II of abdomen; in lateral aspect, the petiole is obliquely truncate posteriorly. Length of abdomen from segment II to apex, 570 μ, width of segment II 310 μ; the latter widened towards apex, abruptly narrowed triangularly in posterior portion. Hind tibiae, length 345-363, hind tarsi, length 380-400 μ.

Habitat: Of this species which does not agree with anyone of those hitherto described, the author possesses two females that were taken in Austria (Sarleinsbach, 7.ix.1932) on sweeping forest grasses (leg. J. Kloiber).

The heavy antennal club (13th segment) is in this species similar to that of *M. cincta* Hal.; but this species has much heavier antennae with joints being transverse from 4th onwards, and its petiole is much longer as compared to the hind coxae. The author has compared with specimens of *M. cincta* from France.

Monelata petiolaris (Nees)

1834, *Diapria petiolaris* Nees, Hym. Monogr., 2, p. 330 (male).
1857, *Diapria* (*Corynopria*) *petiolaris* Haliday, Nat. Hist. Rev., 4, p. 170 (male and female).
1916, *Monoleta petiolaris* Kieffer, Tierr., 44, p. 244 (male).

Following the description of a species the author considers identical with Nees' *Diapria petiolaris*.

Female: Black, thorax laterally, propodeum and abdominal segment II at base somewhat reddish, petiolus fulvous. Legs (inclusive of coxae) and antennal joints 1-3 fulvous, terminal tarsal joint sometimes darkened, the intermediate antennal joints gradually darker towards apex of antenna,

dull reddish to brownish, club joint wholly dark or with tip paler. Head somewhat more conspicuously pilose than in the former species, thorax with fur, the adpressed hairs of the propodeum whitish, as are those of the petiole and the base of abdominal segment II.

Scape, length about 295 μ, curved, rather thick, breadth 52 μ; joints 2-13 combined measuring at least 760 μ; joints 2-4: 104(47), 70(35), 43(35) μ long (broad) respectively; joint 5 as long as broad, the following joints increasing in width, joints 11-13: 52(52), 52(60) and 173-182(83-87) μ long (broad). Thorax as in the foregoing species. Wings 1290-1330 μ long, 424-450 μ broad, fringe hairs at apical margin 95-105, at hind margin (longest hairs) 120-138 μ long; length of wing from base to apex of marginalis about 485 μ. Petiole elongate, 155-173 long, 87-105 μ broad (in dorsal aspect), length of abdomen from segment II to apex: 796, width of segment II: 400-415 μ; segment II is elongate oval with tip shortly triangularly pointed. Hind tibiae, length 400, hind tarsi, length 430 μ. — Total body length: 1.4-1.7 mm.

Habitat: Two specimens of this species were taken by J. Kloiber in September and October, near Linz in Upper Austria.

The author possesses a series of males (Austria: Linz, Schlierbach and Sarleinsbach) which he considers to belong to the females described above, since they agree in the shape of the thorax, the colour and pubescence, the petiole and legs, very well with them. It has to be mentioned, however, that the antennae of these males are in all specimens 14-segmented. The author has never seen a male of this genus having 13-segmented antennae, while Kieffer, though he had never seen a male himself, mentioned 13 segments in the generic description (l.c., p. 243). The description of this form is as follows:

Head dark, thorax and base of segment II of abdomen reddish, petiole fulvous, legs and antennal joint 1 of the same colour, 2 fulvous, slightly shaded, the remaining antennal joints brown to blackish-brown.

Length of antennae from joint 2-14: 1310-1330 μ; scape, length 242-260, joint 2: 87 μ, the following joints each about 105 μ long, 35-38 μ broad, joint 14, length 140 μ. In the largest specimens, joint 14 is 173 μ, the intermediate joints are 113-120 μ long. The antennae are finely yellowish, nearly adpressedly pilose. Head, width 277 (in the largest specimens 328) μ, thorax, width 275 (in the largest specimens 303) μ. Pubescence of propodeum and petiole and also of base of abdominal segment II as in the female. Wings, length 1330, width 415; fringe longer than in the female, at apical margin 140-155, at posterior margin about 173 μ. — Total body length: 1.26-1.47 mm.

Monelata pallipes spec. nov.

Female : Black, shining, legs (inclusive of coxae) yellow, ultimate tarsal joint somewhat darkened, antennae fulvous, joints 11 and 12 slightly darkened, joint 13 (club) dark. Costa and marginalis ferrugineous. Petiole sometimes dark reddish brown.

Head from eyes narrowed, sides of temples straight, width 277 μ; thorax, width 277 μ. Scape thick, somewhat curved, 277(43-45) μ long (broad), longer than the five but shorter than the six following joints combined; joint 2 long, from base about 104 μ long, 38-40 μ broad, joint 3 only about 43 μ long, 29-31 μ broad, joint 4: 35 μ long and 35 μ broad, joint 11: 47 (45) μ long (broad), joint 12 nearly globular, 48(52) μ long (broad), joint 13 (club) 164-173 μ long, 87 μ broad. Length of segments 2-13 combined: 657-675 μ. Thorax with fur in front (at the sides), scutellum as in *clavigera*, hind margin indistinctly margined. Wings, length 1280-1300, width 458 μ, fringe at apical margin 105, at posterior margin 120 μ; length of costa from base to apex of marginalis 433 μ. Sides of propodeum not very densely pubescent, petiole somewhat more densely so, nearly adpressedly pilose. Carina of propodeum, in lateral aspect, convex in front, strongly concave at the declivous posterior portion. Petiole short, thick. Abdomen, length from base of segment II to apex of abdomen 605 μ. Length of hind tibiae 345-364, of hind tarsi about 380 μ. — Total body length: 1.44-1.64 mm.

Habitat : Two females, Austria (Kahlenberg near Vienna), 11.v. 1937 and 5.v.1938 (leg. Blühweiss).

This species differs from *petiolaris* Nees (sensu Priesner) by the longer antennal joint 2, the more slender flagellar joints, the finer pilosity of the sides of the propodeum and the darker coloration, from *clavigera* it is easily distinguished by the much smaller club joint.

Monelata aegyptiaca spec. nov.

Female : Black, thorax dark reddish, scape yellow, flagellum greyish yellow, all flagellar joints somewhat infuscated, gradually darkened towards apex of antennae, club-joint dark. Legs yellow.

Head about as broad as thorax, 250 μ, thorax 246 μ, scape bacilliform, somewhat longer than the five following joints combined; antennal joints distinctly pubescent, intermediate flagellar joints gradually widened towards apex of antennae; scape, length 216-255 μ, joint 2, length 70, joint 3: 45 μ; width of intermediate joints 25 μ; joint 12, length (width) 43(57-59), joint 13: 138(78) μ; antennal joints from joint 2 to 13 combined 398 μ long. Thorax as usual, propodeal carina convex anteriorly, concave posteriorly, as a whole, blunt. Fore wings well 2.4 times as long as broad, length 1090, width 398 μ; fringe, length (at apex of wings) 78-87 μ. Length of

abdomen (from segment II) 570 μ. Hind tibiae, length 310, hind tarsi 337 μ. Shape of abdomen as usual. — Total body length: 1.25 mm.

Habitat: 1 female, Egypt, Meadi.

This species comes closest to *rufipes* Kieff. and *pallipes* n. sp., both European; the former, unknown to the author, has (according to Kieffer) scape and legs red, flagellum dark brown, antennals 3-10 subequal in width and 11 and 12 transverse, of equal width; in our Egyptian species joint 12 is distinctly broader than joint 11, the latter being broader than the foregoing joint. *M. pallipes* is larger, has antennae stouter, their club joint considerably longer, and the body is entirely black.

Monelata parvula (Nees)

1834, *Diapria parvula* Nees, Hym. Monogr., 2, p. 324 (females).
1916, *Monoleta parvula* Kieff., Tierr., 44, p. 244 (females).

To this species the author is referring the following one of his collection:

Female: Smaller than the other species and having in all cases greyish-testaceous to pale brownish clubs of femora and tibiae. Black, shining, legs yellow, femora and sometimes also tibiae with clubs slightly shaded. Petiole and also thorax sometimes dull *dark* brownish or reddish. Antennae dull fulvous, none of the joints being clear yellow, also scape, usually on dorsal surface, infuscated.

Head and thorax 208-242 μ broad. Scape similar in shape to that of other species but shorter, 225 μ long, joint 2: 78(31-35), joint 3: 42(23) μ long (broad); flagellar joints from joint 5 not longer than broad, joint 10: 29(31), 11: 35(42-43), joint 12: 35(52), joint 13: 130(78) μ long (broad); joints 2-13 combined 500-520 μ long. Wings, length 1000-1060, width 330-380 μ (in the largest specimens 415 μ), fringe, length 87-105, at hind margin 120 μ. Length of costa + marginalis 295-330 μ. Abdomen much widened towards apex, where it is nearly truncate, the terminal segments forming a very short, blunt triangle; length of segment II to apex of abdomen 450-485 μ, width of segment II: 260-310 μ. Hind tibiae, length 277, hind tarsi 295 μ. — Total body length: 0.98-1.25 mm.

Habitat: Austria. The author has seen 15 females from various parts of Upper and Lower Austria, that were taken from May to October. Formerly known from Germany and Sweden.

Key to the palaearctic species of Monelata

1 (4) Club-joint (13th antennal) very large, sometimes five times as long as joint 12, in any case at least 200 μ long.

2 (3) Antennal joint 4-10 as long as broad or scarcely transverse, joint

11 slightly transverse; flagellum very slender; club length 194-200 μ. Petiole shorter than hind coxa..... **clavigera spec. nov.**

3 (2) Antennal joints 4-11 transverse. Flagellum yellow, club black. Petiole as long as hind coxa. Length 0.7-1.8 mm..... **cincta (Hal.)**

4 (1) Club-joint smaller.

5 (8) Petiole yellowish or fulvous; pleurae sometimes ferrugineous.

6 (7) Antennals 4-10 transverse, 11 and 12 globular, somewhat thicker, club 2-3 times as broad as joints 11 or 12; antennae yellow, club black. Basalis, medialis and analis faintly developed. Length 1.2-1.5 mm. ..... **pleuralis Kieff.**

7 (6) Antennals 4-12 square to globular, not transverse. Wings without veins, except subcosta and marginalis. Ultimate antennal joint less than twice as long as joints 11 and 12 combined..... **petiolaris (Nees)**

8 (5) Petiole dark. Antenals 11 and 12 transverse. Club joint not twice as broad as joint 12.

9(14) Legs (inclusive of coxae) yellow or fulvous, without darkenings.

10(13) Legs and antennae (except dark club) yellow.

11(12) Intermediate flagellar joints stouter, width 29-35 μ; club, length (width) 164-175(87) μ. Thorax black. Length 1.4-1.6 mm. .... **pallipes spec. nov.**

12(11) Intermediate antennal joints more slender, width 25 μ; club, length (width) 138(78) μ. Thorax reddish. Length of body 1.25 mm. ... . **aegyptiaca spec. nov.**

13(10) Black, legs red, flagellar joints dark brown..... **rufipes Kieff.**

14 (9) Legs always somewhat shaded with grey or brown, at least club of femora and tibiae infuscated. Abdomen much widened towards apex, nearly truncate. Flagellum comparatively very slender, intermediate joints at most 23 μ in width; club, length 130-140 μ. Body length 0.98-1.3 mm. ..... **parvula (Nees).**

3. REMARKS ON DIAPRIA LATR. AND ALLIED GENERA

In the author's first paper on the *Diapriidae* (*Bull. Soc. Fouad I d'Entomologie*, 1940, pp. 71-81) a Key was given to the species of *Trichopria*. In this key a new species of *Phaenopria* was mentioned under the name of *Ph. alexandrina* sp. n. A closer study of the genus *Trichopria* (sensu Kieffer) and its allies has convinced the author that this species is much better placed in « *Trichopria* ». This new species is described below.

The author is making use of this opportunity to make some remarks on the nomenclature of the genera allied to *Diapria*, viz., this genus, *Trichopria* Ashm. and *Ashmeadopria* Kieff.

The old genus *Diapria* Latr. was divided by Ashmead (3) into several genera, viz. : *Tropidopria* Ashm., *Diapria* Latr., *Ceratopria* Ashm., and *Trichopria* Ashm. As type of *Diapria* Latr. has to be taken *D. conica* (F.) (sc. *Ichneumon conicus* F.). For this reason *Tropidopria* is an outright synonym of *Diapria*, since Ashmead designated as type of it the same *Diapria conica* F.

The genus *Diapria* can, as to the author's opinion, be characteried by the possession of their members of an angular incision at the base of tergite II of the abdomen, which is wanting in all species belonging to the other genera of this group. Other characters, as e.g. the elongate-conical tip of the abdomen and the sharp carina on the scutellum are (more or less conspicuously) present in species of other genera as well, and do, therefore, not come in as differentiating characters, between *Diapria* (s.str.) and the rest. Moreover, a new species of *Diapria* was discovered by the author (in Austria) which is characterized by a short abdomen and a quite inconspicuous carina on the scutellum but which shows clearly the excavation at the base of tergite II, typical for *Diapria*. To this species I gave the name : *Diapria transiens* sp. n. It is briefly described below.

The other genera that Ashmead tried to separate as such could not all be maintained at the same rank, but Kieffer has kept *Trichopria* and created *Ashmeadopria* (for *Tropidopria* p. p.). *Diapria* Ashm. (nec Latr.) he renamed in *Planopria*, maintained it as subgenus under *Trichopria* and treated *Ceratropia* Ashm. alike.

It remains, therefore, as result that we have according to Kieffer two genera (besides *Diapria*), namely : *Trichopria* (comprising the species without scutellar keel) and *Ashmeadopria* (those with scutellar keel). The males of *Ashmeadopria* possess all regular whorls of raised hairs on the antennal joints, while those of *Trichopria* are either irregularly pilose or pubescent, or have regular whorls, as this is the case in *Ashmeadopria*. Not realizing the mistake Kieffer made in taking the presence or absence of the scutellar carina as of generic value, he was forced to divide *Trichopria* into subgenera (according to the difference in the pilosity of the antennal joints). Thus it appears that one of the chief characters of *Ashmeadopria* (whorls of hairs in the male sex) is also present in one of the subgenera of *Trichopria*, namely in *Planopria* Kieff., a certainly untenable state of affairs.

It would be an acceptable solution of this nomenclatorial difficulty — which is aggravated by the fact that Kieffer wrongly gave *Trichopria* Ashm. priority over *Ceratropia* Ashm. — if we put all species having verti-

(3) *Bull. U. S. Mus.*, 45, 1893.

cillate pilosity of the antennae (with or without conspicuous scutellar keel) into one genus: *Planopria* Kieff. (with *Ashmeadopria* (1911) as a synonym), whilst the remaining species (i.e. those having shorter or longer *irregular* pilosity) we would combine under *Ceratopria* Ashm. (not *Trichopria* Ashm., as this genus is described p. 431, *Ceratopria*, however, on p. 428). But this arrangement is not practical because we are not able yet to assign the females to the respective males of most of the species.

The most reasonable course to be taken seems, therefore, to retain one single genus only, and this for the present, without any subdivisions. This genus has to be called: *Ceratopria* Ashm. and comprises Kieffer's genera *Ashmeadopria*, *Trichopria* (with all its subdivisions) and also *Neodiapria* Kieff. which latter genus combined the male character of *Ashmeadopria* with the male character of *Trichopria* Kieff. (p. p.).

Following the descriptions of the above mentioned *Ceratopria alexandrina* sp. n. and *Diapria transiens* sp. n.

Ceratopria alexandrina spec. nov.

Female (brachypterous). : Head (dorsally), 2nd and following abdominal segments black, thorax dark reddish-brown above, pleurae and petiole fulvous or brownish-yellow, club dark, blackish. Tarsal joint 5 dark.

Head somewhat transverse, eyes nearly only one-half of occiput, sides of head slightly rounded, narrowed; antennal hump conspicuous, transverse; head, in lateral aspect, higher than long; eyes practically bare; ocelli present, not approximate. Scape slightly curved, somewhat longer than joints 2-5 combined, sides rather even; joint 2 elongate, somewhat thinner than scape but distinctly thicker than joint 3; the latter well twice as long as broad, slightly widened towards apex, 4-6-7 slightly elongate, 8 and 9 as long as broad, 8 little broader than 7, 9 little broader than 8, 10-12 forming an indistinctly separated club; joint 11 being distinctly broader than long, broader than 10, 12 about as long as the two preceeding joints combined; directed backwards the antennae surpass somewhat the base of the abdomen. Occiput posteriorly, prothorax and propodeum densely greyish-white pubescent. Thorax much flattened dorsally, with fine scutellar suture; scutellum very slightly convex, slightly depressed in front, but without foveola, though with a very short incised line on either side at base. Wings somewhat reduced, narrow, whitish, elongate-elliptical, slightly pointed, covering the first third of the abdomen. Petiole possibly broader than long. *Abdomen much broader than head or thorax*, sides convex, broadest at posterior third, abruptly pointed from the latter onwards; in strongly contracted specimens this abrupt narrowing from segment II to the following segments is even more pronounced, so much so that segment II appears to have blunt pos-

terior angles; segment III short, but somewhat longer than IV, scarcely shorter than V; tip of abdomen rather sharp. Middle tibiae slightly sigmoid in shape, hind tibiae slightly incrassate for more than the posterior third. Chaetotaxy normal, much denser within than without.

Measurements: Head, width 330. Thorax, width 260. Wings, length 570-590, width 120. Abdomen, length from segment II to apex: 830-848, width of segment II: 450. Hind tibiae, length 398-407, hind tarsi, length 380-398. Antennal joints: 260(43), 70(38-40), 76(28), 43, 43, 43, 48, 43(25), 48(43), 52(52), 60(64), 120(70); segments 2-12: 657-675 μ. — Total body length: 1.66-1.68 mm.

Habitat: Alexandria (Mex), 4.viii.1938 (leg. A. Rabinovitch).

Diapria transiens spec. nov.

Female: Black, shining, joints 2-6(-7) of antennae dark reddish-brown, remaining joints black. Legs with coxae, clubs of femora and tibiae, 5th tarsal joint brownish-black, the remaining parts dull yellowish-red. Subcosta yellow, marginalis brown, base of wing slightly yellowish, a curved lineola is indicated. Fur at temples whitish, that on fore angles of thorax grey.

Head narrowed from eyes to base, nearly in a straight line, strongly convex posteriorly, sparingly set with long hairs, with pale fur at temples. Antennae long, all joints elongate, scape rather evenly broad, rough, joint 2 somewhat shorter than 3, as long as 4 or 5; antennae gradually thickened towards apex. Prothorax with very dense fur so that it appears evenly truncate in front; mesonotum rounded behind fur, convex, but depressed posteriorly above; scutellum with large fovea that is smooth, not striate and the sides of which are narrowed towards apex; carina in posterior portion fine, not reaching into fovea, sides of scutellum margined, hind angles pointed. Propodeum with very dense whitish pubescence, carina strongly protruding, in lateral aspect, though wholly rounded, not angular. Declivous part of thorax at the sides of the scutellum shortly whitish pubescent. Petiole longer than broad, set with long raised hairs, particularly in its posterior half. Wings broad, 2.4 times as long as broad, *sc + marg* short, much less than one-third of wing length, fringe short. Abdomen elongate-oval in outline, only *very shortly pointed at apex*, tergite II at fore margin with a sharp incision forming a pointed angle with concave sides; segments III and IV subequal in length, short; apex of abdomen sparingly pilose, segment II bare. Hind tibiae club-shaped in posterior third, very densely set with bristles at interior margin, apex with stout spur exteriorly, exterior margin set with longer scattered bristles. Hind tarsi somewhat shorter than hind tibiae.

Measurements in μ: Head, length 484, width 476; diameter of eye 156-165. Antennae, length from segment 2 to 12: 1350; lengths (breadths) of joints: 433-450(69), 120(52-55), 156(52), 120, 120, 104, 104, 104(73), 120(83), 113-120(90), 120(95), 164-173(87). Thorax, width 588. Wings, length 2455, width 1003, fringe length at apex of wing 87; length of subcosta + marginalis 554-570. Petiole, length 310, width (?) 175; length of abdomen from segment II to apex: 1176-1210, length of segments III or IV: 43-47; width of segment II: 657. Hind tibiae, length 727-745; hind tarsi, length 657-675, segments of hind tarsi: 60, 138, 87, 78 and 130. — Total body length : 3 mm.

Habitat : Austria, Linz (Trauauen), 30.viii.1947. — One female (leg. H. Priesner).

This species can hardly be confused with anyone of those hitherto described; it differs from *conica* and allies by the only shortly pointed abdomen, the short, weak scutellar carina, the smooth scutellar fovea and the more elongate distal antennal joints.

Beitrag zur Systematik der Gattung *Geotomus* Muls.-Rey

[Hemiptera Heteroptera : Cydnidae]

(mit 89 Abbildungen)

von Eduard Wagner, Hamburg-Lgh. 1

I. DIE TRENNUNGSMERKMALE

Die Trennung der Arten der obigen Gattung erweist sich nach den bisherigen Bestimmungswerken als recht schwierig, oft sogar als undurchführbar. Das liegt vor allem daran, dass die bisher für die Trennung der Arten benutzten Merkmale in manchen Fällen versagten. Das ist vor allem dann der Fall, wenn man Material aus dem Mittelmeergebiet bearbeiten möchte. Es galt hier also zunächst die bisher benutzten Merkmale einer gründlichen Kritik zu unterziehen und dann nach besseren Merkmalen zu suchen, die sich auch hier wie in vielen anderen Fällen im Bau der Genitalien fanden. Dabei stellte sich heraus, dass auch einige neue, bisher unbeschriebene Arten vorhanden waren. Sie werden weiter unten beschrieben. Aber auch einige der bekannten Arten konnten genauer abgegrenzt werden.

1. Die Gestalt (Fig. 1-13)

Nach ihr lassen sich zwar die beiden mitteleuropäischen Arten, *G. punctulatus* Costa (Fig. 4) und *G. elongatus* H. S. (Fig. 9) gut trennen. Bei ersterem sind die Aussenränder der Halbdecken deutlich nach aussen gebogen, während sie bei der letzteren im basalen Teil fast gerade und parallel sind. Die übrigen Arten gehören dann entweder dem *punctulatus*-Typ (Fig. 1, 3, 4, 6, 7, 8) oder dem *elongatus*-Typ (Fig. 9-12) an, so dass sich nach der Gestalt die Gattung in zwei Artengruppen teilen liesse, wenn nicht eine dritte Gruppe von Arten vorhanden wäre, bei der man im Zweifel sein kann, zu welcher der beiden Gruppen sie zu stellen wären (Fig. 2, 5, 13). Von diesen ist jedoch *G. laticollis* Reut. (Fig. 2) an der Form des Pronotum gut zu erkennen. Immerhin lässt sich dies Merkmal in vielen Fällen gut verwenden.

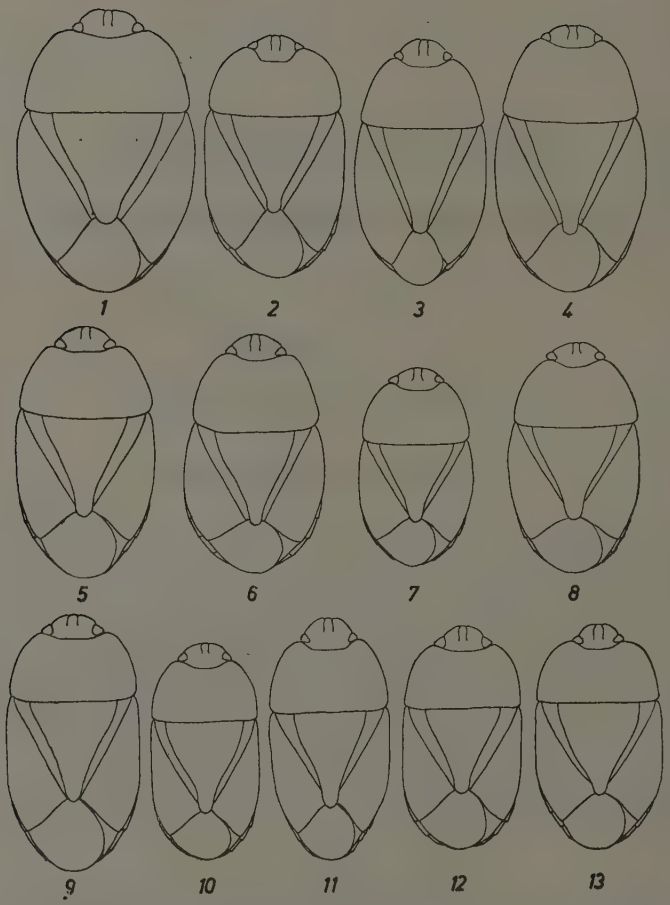

Fig. 1-13. Gestalt des ♂ (9×): 1. *G. latiusculus* Horv.; 2. *G. laticollis* Reut.; 3. *G. antennatus* Sign.; 4. *G. punctulatus* Costa; 5. *G. brunnipennis* n. sp.; 6. *G. simillimus* n. sp.; 7. *G. caucasicus ciliatitylus* Sign.; 8. *G. caucasicus caucasicus* Klti.; 9. *G. elongatus elongatus* H. S.; 10. *G. elongatus angustus* n. sbsp.; 11. *G. longicornis* n. sp.; 12. *G. intrusus* n. sp.; 13. *G. algiricus* Vid.

2. Die Behaarung

Der Aussenrand des Corium trägt bei den meisten Arten der Gattung im basalen Teil einige grubenartige Vertiefungen, in denen lange Haare sitzen (Porenpunkte). Auch dann, wenn die Haare abgerieben sind, kann man die Vertiefungen bei seitlicher Betrachtung des Randes noch gut

erkennen. Als Merkmal wird ihre Zahl verwandt. Sie soll z. B. bei *G. punctulatus* jederseits 2-4 betragen, während für *G. elongatus* nur 1 angegeben wird. Leider ist dies Merkmal nicht zuverlässig, denn es gibt Tiere von *G. elongatus*, die einen zweiten Porenpunkt aufweisen; ich sah auch schon bei mehreren Arten Tiere, bei denen die Zahl der Punkte auf der rechten Seite eine andere war als auf der linken Seite. Ist man sich dieser Schwankungen bewusst, so kann man auch dies Merkmal mit heranziehen.

Auch die Behaarung des Kopf-Vorderrandes wird oft als Trennungsmerkmal benutzt. Hier findet sich ein gutes Merkmal. Bei einer Reihe von Arten trägt die Stirnschwiele, die bei *Geotomus* stets frei durchlauft, auf ihrem Vorderrande zwei lange aufrechte Borsten (Fig. 19, 20, 21, 23, 25), bei anderen ist sie völlig frei von Borsten. Dies Merkmal ist gut geeignet, um die Arten zu erkennen; leider gibt es jedoch stets auch Tiere, bei denen diese Borsten abgerieben sind und es ist dann oft schwer, ihre Ursprungsstellen zu erkennen. Das macht dies sonst zuverlässige Merkmal in manchen Fällen ungeeignet. Die Feststellung der Anzahl der Borsten auf dem Vorderrand der Wangen und dem Seitenrand des Pronotum führt zu keinen befriedigenden Ergebnissen, da sie Schwankungen unterliegt und im Einzelfall schwer festzustellen ist.

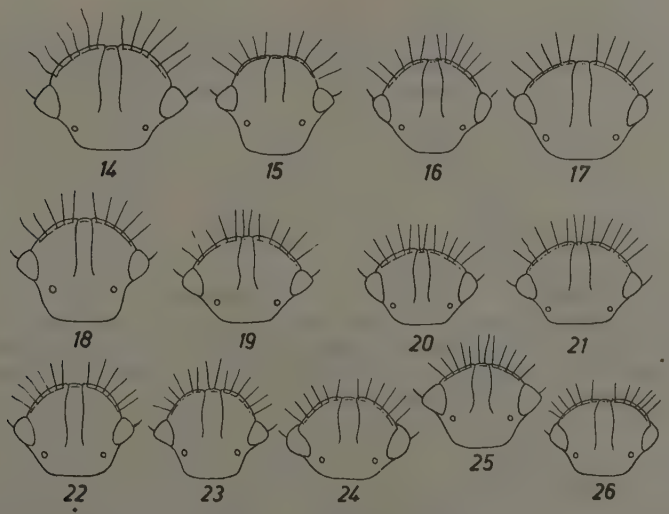

Fig. 14-26. Kopf des ♂ von vorn (18×) : 14. *G. latiusculus* Horv.; 15. *G. laticollis* Reut.; 16. *G. antennatus* Sign.; 17. *G. punctulatus* Costa; 18. *G. brunnipennis* n. sp.; 19: *G. simillimus* n. sp.; 20. *G. caucasicus ciliatitylus* Sign.; 21. *G. caucasicus caucasicus* Klti.: 22. *G. elongatus elongatus* H. S.; 23. *G. elongatus angustus* n. sbsp.; 24. *G. longicornis* n. sp.; 25. *G. intrusus* n. sp.; 26. *G. algiricus* Vid.

3. Die Form des Kopfes (Fig. 14-26)

Wenn man den Kopf von vorn betrachtet, zeigen sich in seiner Form deutliche Unterschiede. Es gibt Arten, die an ihr leicht zu erkennen sind (*G. laticollis* Reut., Fig. 15, *G. intrusus* n. sp., Fig. 25); andere aber zeigen hier nur geringe Unterschiede. Dann aber lassen sich die Grössenverhältnisse (Scheitelbreite: Augenbreite, Länge des Kopfes: Breite) verwenden. Sie unterliegen zwar Schwankungen; jedoch sind diese nicht so gross, dass sie die Trennung unmöglich machen. Es gibt jedoch auch Fälle, in denen die Unterschiede so gering sind, dass auch dies Merkmal versagt. Vor allem ist es erforderlich, das Tier stets so zu stellen, dass der Blick senkrecht auf Stirn und Wangen fällt.

4. Die Fühler (Fig. 27-39)

Bereits Signoret (1881 + 1885) benutzt die Längenverhältnisse der Fühlerglieder als Trennungsmerkmal. Es eignet sich auch in manchen Fäl-

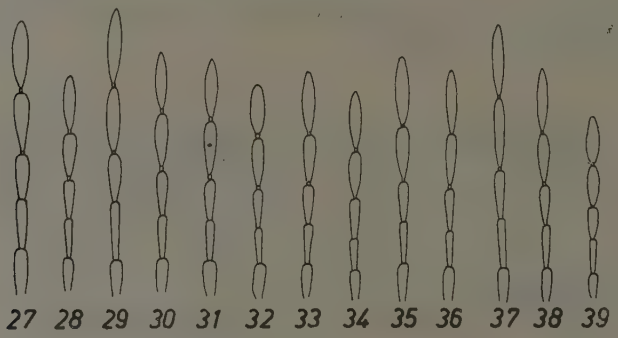

Fig. 27-39. Fühler des ♂ (22,6×) : 27. *G. latiusculus* Horv.; 28. *G. laticollis* Reut.; 29. *G. antennatus* Sign.; 30. *G. punctulatus* Costa; 31. *G. brunnipennis* n. sp.; 32. *G. simillimus* n. sp.; 33. *G. caucasicus ciliatitylus* Sign.; 34. *G. caucasicus caucasicus* Klti.; 35. *G. elongatus elongatus* H. S.; 36. *G. elongatus angustus* n. sbsp.; 37. *G. longicornis* n. sp.; 38. *G. intrusus* n. sp., 39. *G. algiricus* Vid.

len recht gut, vor allem dann, wenn man die Längen wirklich misst und nicht nur schätzt. Die ungewöhnlich langen Fühler von *G. antennatus* Sign. (Fig. 29) und *G. longicornis* n. sp. (Fig. 37) fallen jedoch auch schon bei einfacher Betrachtung auf. Manche Arten, z. B. *G. punctulatus* Costa (Fig. 30) und *G. brunnipennis* n. sp. (Fig. 31) stimmen hier weitgehend überein und können daher durch dies Merkmal nicht getrennt werden.

5. Die Mittel- und Hinterbrust (Fig. 40-49)

Fast alle Arten der Gattung *Geotomus* haben auf Mittel- und Hinterbrust je eine matte, glanzlose, fein punktierte Fläche. Form und Ausdehnung dieser Flächen sind bei manchen Arten so charakteristisch, dass sie ein gutes Trennungsmerkmal abgeben, z. B. *G. latiusculus* Horv. (Fig. 40). Besonders eignet sich hierfür die Grenze der matten Flächen gegen den

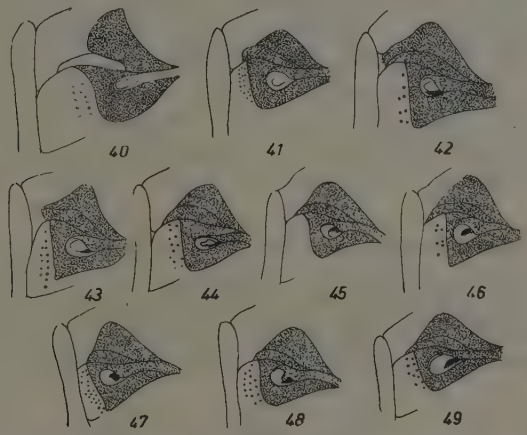

Fig. 40-49. Mittel- und Hinterbrust (25 ×) : 40. *G. latiusculus* Horv.; 41. *G. laticollis* Reut.; 42. *G. punctulatus* Costa; 43. *G. brunnipennis* n. sp.; 44. *G. simillimus* n. sp.; 45. *G. caucasicus ciliatitylus* Sign.; 46. *G. caucasicus caucasicus* Klti.; 47. *G. elongatus elongatus* H. S.; 48. *G. elongatus angustus* n. sbsp.; 49. *G. longicornis* n. sp.

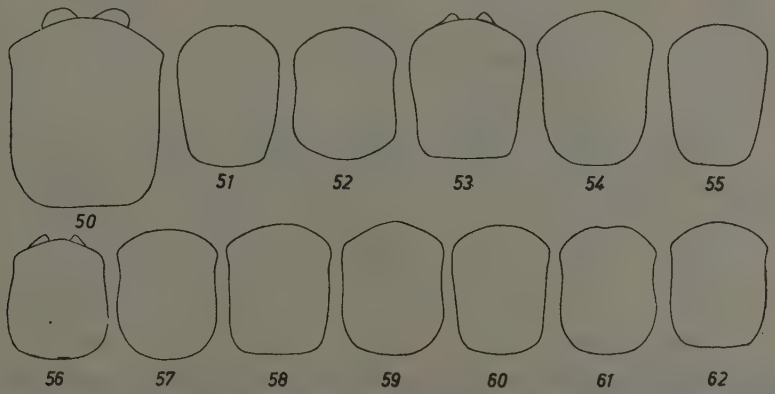

Fig. 50-62. Genitalsegment des ♂, ventral (21 ×) : 50. *G. latiusculus* Horv.; 51. *G. laticollis* Reut.; 52. *G. antennatus* Sign.; 53. *G. punctulatus* Costa; 54. *G. brunnipennis* n. sp.; 55. *G. simillimus* n. sp.; 56. *G. caucasicus ciliatitylus* Sign.; 57. *G. caucasicus caucasicus* Klti.; 58. *G. elongatus elongatus* H. S.; 59. *G. elongatus angustus* n. sbsp.; 60. *G. longicornis* n. sp.; 61. *G. intrusus* n. sp.; 62. *G. algiricus* Vid.

Seitenrand der Brust. Sie können dort gerade begrenzt sein oder spitz auslaufen; sie erreichen bisweilen den Seitenrand der Brust, oft enden sie weit von ihm entfernt. Aber auch dies Merkmal eignet sich nicht für alle Fälle.

6. Das Genitalsegment des Männchens (Fig. 50-62)

Die Form des Genitalsegments ist konstant. Auch hier zeigen sich deutliche Abweichungen, nach denen man zwei Gruppen bilden könnte. Bei der einen ist das Segment stark gewölbt, fast kugelig, vor allem im proximalen Teil rund und erweitert, so dass seine Seiten geschweift erscheinen (Fig. 52, 56, 57, 61, 62). Bei der anderen Gruppe ist das Segment weniger stark gewölbt und seine Seitenränder sind daher fast gerade (Fig. 53, 55, 60). Auch hier gibt es Arten, die zwischen beiden Extremen stehen.

7. Die Genitalgriffel oder Parameren (Fig. 63-76)

Vidal (1949) zieht als Erster die Form der Parameren als Trennungsmerkmal heran und bildet sie bei mehreren Arten ab. Der linke Griffel ist bei *Geotomus* das Spiegelbild des rechten, jedoch zeigen sich bisweilen

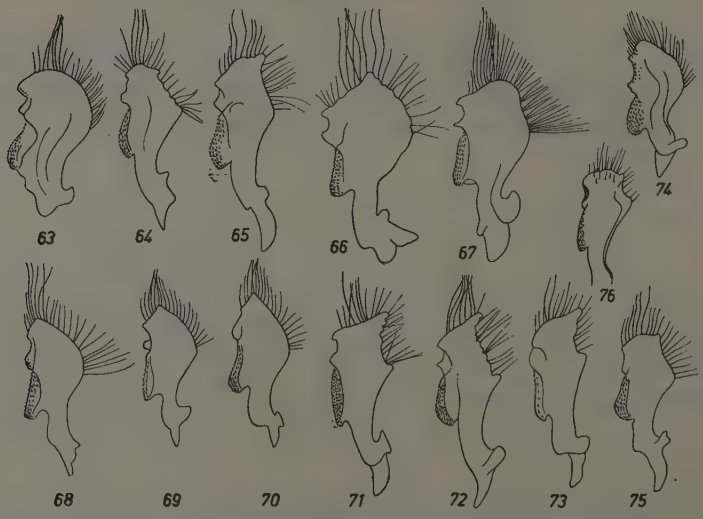

Fig. 63-76. Genitalgriffel des ♂ von vorn (56×) : 63. *G. latiusculus* Horv.; 64. *G. laticollis* Reut.; 65. *G. antennatus* Sign.; 66. *G. punctulatus* Costa; 67. *G. brunnipennis* n. sp.; 68. *G. similimus* n. sp.; 69. *G. caucasicus ciliatitylus* Sign.; 70. *G. caucasicus caucasicus* Klti.; 71. *G. elongatus elongatus* H. S.; 72. *G. elongatus angustus* n. sbsp.; 73. *G. longicornis* n. sp.; 74. *G. intrusus* n. sp.; 75. *G. algiricus* Vid.; 76. *G. regnieri* Vid. (nach Vidal 1949, 47×).

kleine Abweichungen. Die Form der Griffel ist höchst eigenartig. Sie sind flach, leicht gekrümmt und sehen von der Seite etwa wie das Profil eines Menschenkopfes mit Bart aus. Der Bart wird durch eine fein gekörnelte Fläche, die sich im basalen Teil an der Innenkante findet, dargestellt. In der Mitte der Innenkante findet sich ein nasenähnlicher Vorsprung, über dem sehr oft noch ein zweiter Höcker sitzt. Die Aussenkante ist entweder gerundet oder bildet eine Ecke. Der distale Teil des Griffels ist dicht mit feinen Haaren bedeckt, am oberen Rande findet sich oft eine Anzahl kräftigerer Borsten. Die Unterschiede liegen hier vor allem in der Form des Griffels und der Ausbildung von Ecken und Höckern. Bei der Betrachtung muss man beachten, dass die Griffel nicht völlig flach sind und bei Betrachtung von vorn ein etwas anderes Bild ergeben als von hinten.

8. Der Penis (Fig. 77-89)

Der Penis ist stets stark pigmentiert und schwarz gefärbt. Er ist von länglicher Gestalt und die Vesica trägt am distalen Ende 2 Fortsätze, deren Form und Länge taxonomisch gut zu verwerten ist.

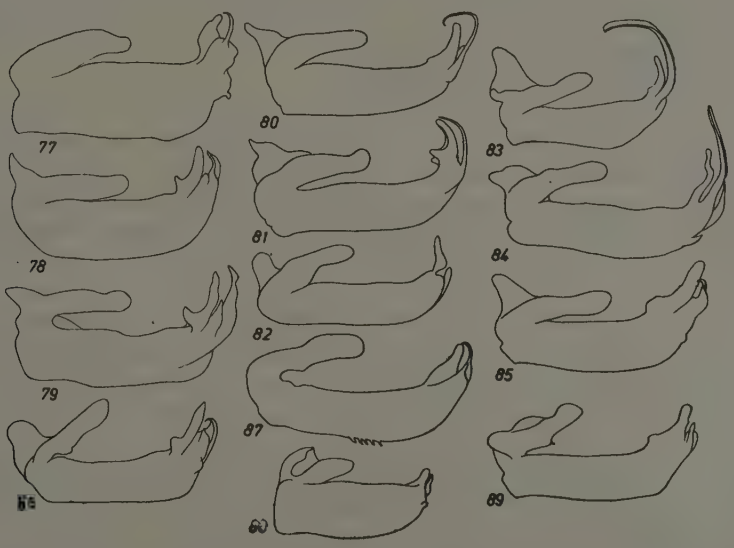

Fig. 77-89. Penis, seitlich (50×) : 77. *G. latiusculus* Horv.; 78. *G. laticollis* Reut.; 79. *G. antennatus* Sign.; 80. *G. punctulatus* Costa; 81. *G. brunnipennis* n. sp.; 82. *G. simillimus* n. sp.; 83. *G. caucasicus ciliatitylus* Sign.; 84. *G. caucasicus caucasicus* Klti.; 85. *G. elongatus elongatus* H. S.; 86. *G. elongatus angustus* n. sbsp.; 87. *G. longicornis* n. sp.; 88. *G. intrusus* n. sp.; 89. *G. algiricus* Vid.

II. NEUE ARTEN UND BEMERKUNGEN ZU BEKANNTEN

1. Geotomus brunnipennis nov. spec.

Gestalt (Fig 5) lang-oval, 1,8-1,9× so lang wie das Pronotum breit ist, Auszenrand des Corium leicht nach aussen gebogen, am Grunde nicht gerade, aber auch nicht so stark gebogen wie bei *G. punctulatus* Costa (Fig. 4). Schwarz bis schwarzbraun, schwach glänzend, Ränder mit langen Haaren.

Kopf (Fig. 18) kurz, sein Vorderrand breit gerundet, Ränder der Wangen mit langen Haaren, Stirnschwiele ohne Haare. Oberseite des Kopfes punktiert, Mitte des Scheitels und Stirnschwiele glatt. Auge klein und leicht gewölbt; Scheitel 4,2-4,3× so breit wie das Auge; Ocellen vom Auge um etwas mehr als die halbe Augenlänge entfernt. Fühler (Fig. 31) kräftig, kurz, schwarzbraun; Längen der Glieder: 1 = 0,22, 2 = 0,26, 3 = 0,26, 4 = 0,38, 5 = 0,43 mm. Das 2.+3. Glied also gleich lang.

Pronotum (Fig. 5) nach vorn stark verengt; Vorderecken gerundet; oberseits fein punktiert, der Hinterrand und eine breite Fläche im vorderen Teile glatt. Scutellum kräftig punktiert, seine Spitze schmal, distal gerundet und leicht eingedrückt. Halbdecken fein punktiert, am Grunde ist die Punktierung kräftiger. Corium distal oft braun, die Subcostalader schwielig erhaben; der leistenartige Rand trägt 1-3 Porenpunkte. Membran gelbweiss, Adern zum Teil undeutlich.

Unterseite chagriniert, Mitte des Bauches fast glatt. Die matten Flächen der Mittel- und Hinterbrust (Fig. 43) berühren einander, die der Mittelbrust erreicht den Seitenrand nicht, ihre seitliche Grenze verläuft quer, die Fläche der Hinterbrust ist distal spitz, neben ihrem Aussenrande 2 Reihen von Punkten. Der Schnabel erreicht die Mittelhüften nicht. Beine schwarzbraun, Schienen mit langen, kräftigen Dornen, Tarsen schlank, gelbbraun.

Genitalsegment des ♂ (Fig. 54) länger als breit, distal deutlich breiter, gewölbt, Seiten leicht geschweift. Genitalgriffel (Fig. 67) gross und breit, distal und aussen breit gerundet, an der Innenkante distal ein spitzer Höcker und dicht darunter ein gleichfalls spitzer Höcker, dessen untere Kante fein gekörnelt ist; bartartige Zone fein gekörnelt und basal mit fast spitzem Vorsprung; der distale Teil des Griffels dicht mit auffällig langen, feinen Haaren bedeckt, an der inneren Kante des oberen Randes einige kräftigere Borsten. Penis (Fig. 81) gross und schlank, die beiden Fortsätze der Vesica etwas länger, der innere kräftig, mit breiter Basis, der äussere schlank, leicht gekrümmt und spitz.

Länge: ♂, ♀ = 4,4-4,8 mm.

G. brunnipennis n. sp. steht in der Form zwischen *G. punctulatus* Costa und *G. elongatus* H. S., hat aber leicht gerundete Coriumränder.

Er unterscheidet sich von *G. elongatus* überdies durch breiteren Scheitel, kürzeres 5. Fühlerglied, kürzeren Schnabel und den Bau der Genitalien, von *G. punctulatus* ist die Art durch breiteren Scheitel, schlankere Gestalt, etwas längeres 5. Fühlerglied und den Bau der Genitalien verschieden.

Ich untersuchte 5 ♂♂ und 7 ♀♀; aus Dalmatien (J. Sahlberg) 3 ♂♂, 1 ♀; Kephallinia (Paganetti) 1 ♀ (R 8118), Skutari Mesi 1 ♂, 5 ♀♀ und Korsika: Bastia (H. Schulz) 1 ♂.

Holotypus und Allotypoid in meiner Sammlung, Paratypoide ebenda und im Senckenberg-Museum (R 8118), im Naturhistorischen Museum Wien und im Museum Helsingfors.

2. Geotomus intrusus nov. spec.

Gestalt (Fig. 12) klein und schlank, vom *elongatus*-Typ, 1,9-2,0× so lang wie das Pronotum breit ist. Glänzend, schwarzbraun bis braun, fast kahl.

Kopf kurz, sein Vorderrand parabolisch; Oberseite überall stark punktartig gerunzelt; Vorderrand der Wangen mit langen Haaren, auch auf der Stirnschwiele 2 Haare. Auge sehr breit und auffallend flach; sein Vorderrand daher fast gerade; Scheitel 2,8-2,9× so breit wie das Auge; Ocellen vom Auge um weniger als die halbe Länge des Auges entfernt. Fühler (Fig. 38) von mittlerer Länge, dunkelbraun, die Spitze des 4. Gliedes und das 5. Glied glanz hellbraun; Längen der Glieder: 2 = 0,30, 3 = 0,25, 4 = 0,36, 5 = 0,40 mm. Das 2. Glied 1,2× so lang wie das 3. und das 5. Glied 1,1× so lang wie das 4.

Pronotum (Fig. 12) glatt, ein Streif am Vorderrande, eine breite Fläche an den Seiten und die Querfurche im hinteren Teil fein punktiert; Seiten nach vorn konvergierend, Vorderecken gerundet. Schildchen zerstreut mit feinen Punkten bedeckt, Spitze schlank, distal gerundet. Halbdecken fein punktiert, am Grunde eine kräftiger punktierte Fläche, die auf das Scutellum übergreift. Der Aussenrand des Corium ist schmal leistenartig und in der Regel frei von Porenpunkten. Membran weisslichgelb, Adern deutlich.

Unterseite glänzend, kräftig punktiert. Mittel- und Hinterbrust ohne matte Flächen, überall glänzend und kräftig punktiert, die Ränder der Pleuren glatt. Der braune Schnabel reicht bis zum Grunde der Mittelhüften. Beine schwarzbraun, Schienen mit sehr langen, schlanken Dornen. Tarsen gelblich, sehr schlank.

Genitalsegment des ♂ (Fig. 61) etwas länger als breit, stark gewölbt, seine Seiten eingebuchtet. Genitalgriffel (Fig. 74) aussen gerundet, ohne Höcker, distal abgerundet und mit feinen, verhältnismässig kurzen

Haaren, distal innen mit kleinem Höcker, in der Mitte ein stumpfer Vorsprung und darunter eine lange fein gekörnelte Fläche, die nach aussen gewölbt ist und proximal stark vorspringt. Penis (Fig. 88) auffallend kurz und dick, beide Fortsätze der Vesica sehr kurz und kaum zu erkennen.

Länge : ♂, ♀ = 4,0-4,4 mm.

G. intrusus n. sp. hat die gleiche schlanke, parallelseitige Gestalt wie *G. elongatus* H. S., ist aber kleiner und unterscheidet sich von dieser Art durch das ungewöhnlich grosse und flache Auge, das Fehlen matter Flächen auf Mittel- und Hinterbrust, das längere 2. Fühlerglied und den Bau der Genitalien. Auch von allen übrigen Arten ist er leicht durch das Fehlen der matten Flächen und das grosse Auge zu trennen, sowie durch das Vorhandensein zweier Borsten auf der Stirnschwiele. Er steht *G. parallelus* Manc. aus Mittelafrika recht nahe und stimmt mit dieser Art darin überein, dass die Bruststücke keine matten Flächen haben, unterscheidet sich aber von ihm durch das Vorhandensein von 2 Haaren auf der Stirnschwiele, den überall kräftig punktierten Kopf, das längere 2. Fühlerglied und feiner punktierte Bruststücke.

Ich untersuchte 12 ♂♂ und 14 ♀♀ aus Aegypten : Kairo (Sahlberg) 5 ♂♂, 2 ♀♀ ; Pyramiden 22.9.33 (H. Priesner) 3 ♂♂, 6 ♀♀ ; Mansuria 21.9.23 (H. Priesner) 2 ♂♂ ; Maadi 30.5.30 (H. Priesner) 2 ♂♂ ; Heliopolis 6.14 (A. Andres) 5 ♀♀ ; und Algier : Chot Melrhir 5.91 (Handlirsch) 1 ♀.

Die Art wurde bereits von Sahlberg erkannt und in seiner Sammlung mit dem Namen *intrusus* versehen. Leider hat Sahlberg seine Feststellungen nicht veröffentlicht, so dass die Art als unbeschrieben gelten muss. Ich gebe ihr aber den bereits von Sahlberg gewählten Namen.

Holotypus und Allotypoid in meiner Sammlung, Paratypoide ebenda und im Senckenberg-Museum (R 8164, R 8165, R 8166, R 8167, R 8169), in der Sammlung H. Priesner in Kairo, im Naturhistorischen Museum Wien und in den Sammlungen der Universitäten in Helsingfors und Abo, Finnland.

3. Geotomus longicornis nov. spec.

Gestalt (Fig. 11) vom *elongatus*-Typ, aber nach hinten deutlich verjüngt; Pronotum etwas breiter als die Halbdecken in Höhe der Schildchenspitze. Fast 2× so lang wie das Pronotum breit ist. Schwarz, stark glänzend, fein punktiert.

Kopf (Fig. 24) kurz und breit, von vorn gesehen 1,5× so breit wie lang; glatt, nur auf den Wangen einige grobe Punkte. Spitze der Stirnschwiele ohne Borsten. Ocellen vom Auge um etwa die halbe Augenlänge entfernt; Scheitel 3,4× so breit wie das grosse, lange Auge. Vorderrand

der Wangen mit 5-6 langen Borsten. Fühler (Fig. 37) braun, auffallend lang und schlank, etwa halb so lang wie der Körper; Längen der Glieder: 1 = 0,30, 2 = 0,34, 3 = 0,30, 4 = 0,46, 5 = 0,52 mm; das 2. Glied also 1,1× so lang wie das 3., das 5. Glied 1,1× so lang wie das 4. und 1,7× so lang wie das 3.

Pronotum (Fig. 11) kurz und breit, stark gewölbt und stark glänzend, glatt, nur in der Querfurche fein punktiert und an den Rändern vereinzelte Punkte. Scutellum glatt, mit einzelnen groben Punkten, Spitze eingedrückt. Halbdecken fein und weitläufig punktiert, an den Adern mit Reihen gröberer Punkte; Subcostalader leicht erhaben; Aussenrand mit 4-5 borstentragenden Porenpunkten. Membran gelbbraun, die Ränder heller.

Unterseite glänzend, glatt, Bauchseiten weitläufig und fein punktiert. Die matte Fläche der Mittelbrust (Fig. 49) kaum weiter nach aussen reichend als die der Hinterbrust, Stinkdrüsenöffnung auf einer runden, breiten Fläche; Seiten der Hinterbrust neben der matten Fläche mit kräftigen Punkten, die 2-3 Reihen bilden. Der Schnabel reicht bis zwischen die Mittelhüften. Beine schwarz, Dornen der Schienen sehr lang und dünn, Tarsen schlank, braun.

Genitalsegment des ♂ (Fig. 60) nur wenig gewölbt, distal etwas verbreitert, Seiten gerade. Genitalgriffel (Fig. 73) sehr lang und schlank, distal eine nach aussen gerichtete Spitze, aussen ein Höcker, der Rand zwischen beiden leicht eingebuchtet und etwas höckerig; an der Innenseite distal ein gerundeter Höcker, der nach vorn gerichtet ist, in der Mitte ein breit gerundeter Höcker, die bartartige Fläche schmal und fast ohne Körnelung; auch die Behaarung sehr schwach. Penis (Fig. 87) lang, schlank, Theca an der ventralen Seite in der Mitte mit 5 Zähnen; Anhänge der Vesica gleich lang, der äuszere geisselartig dünn und leicht gekrümmt.

Länge : ♂ = 3,9-4,2 mm, ♀ = 4,1-4,4 mm.

G. longicornis n. sp. hat die gleiche Gestalt wie *G. elongatus* H. S., ist aber nach hinten etwas verjüngt und unterscheidet sich von allen übrigen Arten durch die auffallend langen Fühler, an denen das 2. Glied nur 1,1× so lang ist wie das 3. und durch das stark glänzende, gewölbte Pronotum, das verhältnismässig grosse Auge und den Bau der Genitalien. Mir ist keine weitere Art bekannt, bei der der Penis unterseits Zähne trägt. Die übrigen Arten vom *elongatus*-Typ haben auch nie mehr als 2 Porenpunkte am Coriumrande, nur *G. regnieri* Vid. hat deren 3-4; bei ihm ist jedoch der Genitalgriffel (Fig. 76) ganz anders geformt, die Hinterbrust hat neben der matten Fläche nur 1 Punktreihe und die Längenverhältnisse der Fühlerglieder sind anders. Ich untersuchte 4 ♂♂, 2 ♀♀ aus Spanien: Carmona, Hof Alamaja 21.5.51, 1 ♂; und Sevilla, Los Palacios 3 ♂♂, 2 ♀♀, sämtlich H. Franz leg.

Holotypus und Allotypoid in der Sammlung H. Franz, Wien, Paratypoide ebenda und in meiner Sammlung.

4. Geotomus simillimus nov. spec.

Gestalt (Fig. 6) vom *punctulatus*-Typ, das ♂ 1,7× so lang wie breit und 1,9× so lang wie das Pronotum breit ist. Aussenrand des Corium stark gebogen. Schwarz glänzend, fast kahl.

Kopf (Fig. 19) von vorn gesehen 1,5× so breit wie lang, Vorderrand breit gerundet, mit langen Haaren besetzt, auch auf der Spitze der Stirnschwiele 2 Haare. Wangen fein punktiert, Scheitel und Stirnschwiele glatt. Scheitel 3,7× so breit wie das leicht gewölbte, breite Auge; Ocellen vom Auge um etwas weniger als die halbe Augenlänge entfernt. Fühler (Fig. 32) gelbbraun; Längen der Glieder: 2 = 0,25, 3 = 0,27, 4 = 0,34, 5 = = 0,36 mm; das 2. Glied ist nur 0,92× so lang wie das 3. und das 5. kaum länger als das 4.

Pronotum (Fig. 6) kurz und breit, seine Seiten nach vorn konvergierend; Vorderecken gerundet, oberseits glatt, nur der Vorderrand, die Querfurche und eine breite Fläche an den Seiten fein punktiert. Scutellum am Grunde glatt, distal fein punktiert, seine Spitze schlank, niedergedrückt. Halbdecken zerstreut fein punktiert, Adern erhaben, der leistenartige Seitenrand trägt 3-4 Porenpunkte. Membran weissgrau, Adern undeutlich.

Unterseite glänzend, fein punktiert, schwarz. Die matte Fläche der Mittelbrust (Fig. 44) reicht viel weiter nach aussen als die der Hinterbrust, sie läuft in eine Spitze aus, erreicht aber den Seitenrand nicht. Die matte Fläche der Hinterbrust ist distal gerundet, neben ihr einige Punkte, die 2 undeutliche Reihen bilden, der Stinkdrüsengang ist schmal, die Fläche, auf der die Oeffnung liegt, klein. Der Schnabel reicht nur bis zur Mittelbrust, sein 3. Glied reicht bis zur Spitze der Vorderhüften. Beine schwarzbraun, Schienen mit langen, schlanken Dornen; Tarsen gelbbraun.

Genitalsegment des ♂ (Fig. 55) lang und kaum gewölbt, Seiten gerade, distal allmählich verbreitert. Genitalgriffel (Fig. 68) schlank, ihr Aussenrand breit gerundet, distal fast eckig, der Innenrand mit 2 Höckern, der distale nur schwach, der mittlere abgerundet, bartartige Fläche grob gekörnelt, mit gerader Aussenkante, proximal stark vorspringend. Der distale Teil des Griffels dicht mit sehr langen Haaren besetzt, die zum Teil länger sind als der Griffel breit ist. Penis (Fig. 82) lang, schlank, die beiden Fortsätze der Vesica ungleich lang, der innere kräftig, leicht gekrümmt, der äussere sehr kurz, abgerundet.

Länge: ♂ = 4,5 mm.

G. simillimus n. sp. hat die ovale Gestalt wie *G. punctulatus* Costa und steht *G. caucasicus* Klti. am nächsten, ist aber grösser und breiter, hat ein

grösseres Auge, ein auffallend kurzes 5. Fühlerglied, einen schmaleren Scheitel, kürzere, dickere Fühler und anders gebaute Genitalien, vor allem ist der äuszere Fortsatz der Vesica ganz anders geformt. Von den übrigen Arten ist er leicht dadurch zu unterscheiden, dass er auf der Stirnschwiele 2 Borsten trägt Ich untersuchte 1 ♂ aus Palastina: Jordan (J. Sahlberg). Holotypus im Zoologischen Museum Helsingfors.

5. Geotomus elongatus angustus nov. subspec.

Gestalt (Fig. 10) klein, schmal eiförmig, vom *elongatus*-Typ, Körperseiten in der Mitte parallel, 1,95-2,05 × so lang wie das Pronotum breit ist. Braun, seltener schwarzbraun, schwach glänzend, Ränder mit feinen, langen Haaren.

Kopf (Fig. 23) verhältnismässig lang und schmal. Stirnschwiele an der Spitze mit 2 langen Borsten, Ränder der Wangen jederseits mit 5-6 langen Borsten, Scheitel 3,3 × so breit wie das kleine, breite Auge. Oberseite des Kopfes kräftig punktiert, die Mitte des Scheitels, der Stirn und der Stirnschwiele feiner punktiert; Ocellen vom Hinterrand des Kopfes etwa doppelt so weit entfernt wie vom Auge. Fühler (Fig. 36) kräftig, Längen der Glieder: 1 = 0,22, 2 = 0,25, 3 = 0,28, 4 = 0,39, 5 = 0,425 mm; das 3. Glied also 1,1 × so lang wie das 2., das 5. Glied das längste und 1,7 × so lang wie das 2.

Pronotum (Fig. 10) nach vorn verjüngt, seine Seiten im hinteren Drittel fast parallel; hinterer Teil und Seiten mit Ausnahme des Randes deutlich punktiert. Scutellum und Halbdecken kräftig punktiert; Adern des Corium erhaben, von Punktreihen gesäumt; der leistenartige Seitenrand trägt einen Porenpunkt. Membran gelblichweiss.

Unterseite glänzend, die matten Flächen der Mittel- und Hinterbrust (Fig. 48) stossen aneinander, diejenige der Hinterbrust distal breit gerundet, die der Mittelbrust reicht kaum weiter nach aussen und ist seitlich schräg begrenzt. Der Schnabel erreicht kaum die Mittelhüften. Beine gelbbraun, bis schwarzbraun; Schienen mit langen, kräftigen Dornen; Tarsen gelbbraun.

Genitalsegment des ♂ (Fig. 59) länger als breit, ziemlich stark gewölbt, distal kaum breiter, Seiten eingebuchtet. Genitalgriffel (Fig. 72) distal in eine lange, nach aussen gerichtete Spitze ausgezogen, aussen eine scharfe Ecke, der Rand zwischen ihr und der Spitze eingebuchtet und stark höckerig, innen 2 Höcker, die nahe beieinander stehen und spitz sind; bartartige Fläche breit, gewölbt, proximal gerundet. Penis (Fig. 86) klein und schlank, Forsätze der Vesica ungleich lang, der innere distal spitz, der äussere kurz und mit sehr kurzer, gekrümmter Geissel.

Länge: ♂ = 3,8-4,0 mm, ♀ = 4,0-4,1 mm.

G. elongatus angustus nov. subspec. scheint eine in Spanien und Nordafrika weit verbreitete Rasse von *G. elongatus* H. S. zu sein. Sie unterscheidet sich von der Nominatrasse vor allem dadurch, dass die Stirnschwiele 2 Borsten trägt und die Gestalt des Tieres auffallend lang und schlank, sowie etwas kleiner ist. Bei *G. elongatus elongatus* H. S. ist überdies die Punktierung viel feiner und das Tier glänzt infolgedessen stärker, die Fühler (Fig. 35) sind länger, die matte Fläche der Hinterbrust (Fig. 47) ist distal spitz. Das Genitalsegment (Fig. 58) ist etwas weniger gewölbt und seine Seiten infolgedessen kaum geschweift; der Genitalgriffel (Fig. 71) distal breiter und weniger spitz, die beiden Höcker der Innenkante sind weiter von einander entfernt und weniger spitz, die bartartige Fläche ist schmaler und gerader. Am Penis (Fig 85) ist der innere Fortsatz der Vesica kräftiger und distal abgerundet, während der äussere eine längere Geissel trägt.

Es hat fast den Anschein, als ob hier eine spec. prop. vorliegt, es gibt aber Tiere, die vor allem im Bau der Genitalien Uebergangsformen zeigen; andererseits ist aber das Fehlen oder Vorhandensein von Borsten auf der Stirnschwiele ein äusserst gewichtiges Merkmal. Vidal (1949) gibt an, dass bei *G. elongatus* H. S. stets 2 Haare auf der Stirnschwiele vorhanden seien; daraus glaube ich entnehmen zu können, dass seine nordafrikanischen Stücke sämtlich zu unserer neuen Rasse gehören.

Ich untersuchte 3 ♂♂ und 2 ♀♀ aus Nordafrika: El Kantara 7. 04 (Gulde) 1 ♀ (R. 8155); St. Charles (A. Théry) 1 ♂ (R. 8154); und Spanien: Cadix 9. 08 (Lehmann) 1 ♂ (R. 8150); Flix, Taragona 8. 15 (Haas) 1 ♀ (R. 8161); Sierra Ronda, Mt. Arastepa (H. Franz) 1 ♂. Holotypus und Allotypoid im Senckenberg-Museum, Paratypoide ebenda, in meiner Sammlung und in der Sammlung H. Franz, Wien.

6. Geotomus caucasicus Klti. 1846

Diese Art hat die gleiche Gestalt wie *G. punctulatus* Costa (Fig. 7+8), ist aber deutlich kleiner und in der Regel von brauner Färbung. Sie ist überdies leicht von *punctulatus* zu trennen, da sie stets auf der Stirnschwiele 2 Borsten hat, die bei *punctulatus* fehlen. Horváth (1917) stellte fest, dass sie mit *G. ciliatitylus* Sign. identisch sei. Das stimmt, aber dennoch finden sich zwischen beiden Formen einige Unterschiede, die mich veranlassen, sie als Rassen eines Rassenkreises auf zufassen. Diese müssen dann *G. caucasicus caucasicus* Klti. und *G. caucasicus ciliatitylus* Sign. heissen.

Von diesen beiden Rassen ist die letztere (Fig. 7) stets erheblich kleiner und nur 3,3-3,9 mm lang, während die Nominatrasse (Fig. 8) 4,0-4,5 mm lang ist. Die Form das Kopfes ist bei beiden etwa die gleiche (Fig. 20+21), beide tragen auf der Stirnschwiele 2 Borsten. Die Fühler (Fig. 33+34) sind bei beiden kurz, bei *G. caucasicus caucasicus* (34) jedoch verhältnismässig

kürzer, vor allem das 2. Glied, das nur 0,75 × so lang ist wie das 3., während es bei *G. caucasicus ciliatitylus* 0,87 × so lang ist wie das 3. Die Längen der Fühlerglieder betragen bei *G. caucasicus caucasicus*: 1 = 0,22, 2 = 0,20, 3 = 0,27, 4 = 0,31, 5 = 0,40; bei *G. caucasicus ciliatitylus*: 1 = 0,21, 2 = 0,20, 3 = 0,23, 4 = 0,31, 5 = 0,34 mm; das 5. Glied ist bei ersterem 1,3 ×, beim letzterem 1,1 × so lang wie das 4. Auch die matten Flächen der Mittel- und Hinterbrust (Fig. 45 + 46) ähneln einander stark, bei der Nominatrasse (Fig. 46) reicht diejenige der Mittelbrust etwas weiter nach aussen und die der Hinterbrust ist distal spitz. Die Genitalsegmente beider Formen sind stark gewölbt, dasjenige von *G. caucasicus ciliatitylus* (Fig. 56) ist distal verjüngt, während das der Nominatrasse (Fig. 57) distal erweitert ist. Die Genitalgriffel (Fig. 69 + 70) unterscheiden sich ebenfalls ein wenig; sie sind bei der Nominatrasse länger, distal spitzer, der obere Höcker ist schwächer und der mittlere Höcker breiter und stumpfer. Am Penis ist bei *G. caucasicus ciliatitylus* (Fig. 83) der äussere Anhang der Vesica länger und stark gekrümmt, der innere kürzer und weniger gekrümmt. Bei der Nominatrasse (Fig. 84) ist der äussere Anhang fast gerade und kürzer, der innere lang und stark gewunden.

Diese Unterschiede reichen zwar für eine Trennung in 2 Arten nicht aus, zumal da sich auch bei Tieren aus Syrien deutliche Uebergänge zeigten. Im übrigen aber zeigte es sich, dass alle Tiere aus dem Kaukasus und Persien zur ssp. *caucasicus caucasicus* Klti. gehörten, alle Tiere vom Balkan, aus Klein-Asien, Syrien und Palästina aber die ssp. *caucasicus ciliatitylus* darstellten.

7. Geotomus laticollis Reut. 1900

Diese Art habe ich bisher falsch beurteilt. Durch das liebenswürdige Entgegenkommen von Herrn Dr. H. Lindberg war es mir möglich, die Holotype, die sich im Zoologischen Museum Helsingfors (Nr. 7678) befindet, zu untersuchen. Das Ergebnis dieser Untersuchung sei hier wiedergegeben:

Gestalt (Fig. 2) länglich-oval, etwas breiter als bei *G. elongatus* H. S. aber nicht so breit wie *G. punctulatus* Costa; Aussenränder des Corium im basalen Teil fast gerade und parallel, 1,7 × so lang wie in der Mitte breit und 1,76 × so lang wie das Pronotum breit ist. Schwarzbraun, glänzend, kräftig punktiert. Kopf (Fig. 15) sehr stark geneigt, oberseits flach, fein punktiert, Mitte des Scheitels fast glatt, leicht gewölbt. Von vorn gesehen ist der Kopf fast so lang wie breit, von oben gesehen erscheint er sehr kurz. Augen kaum gewölbt, klein; Scheitel 3,7 × so breit wie das Auge. Ränder der Wangen im vorderen Teil etwas aufgebogen, mit langen Haaren, Stirnschwiele ohne Haare. Fühler sehr kurz und kräftig (Fig. 28), schwarzbraun. Längen der Glieder: 2 = 0,26, 3 = 0,25, 4 = 0,34, 5 = 0,38 mm;

das 2. Glied also kaum länger als das 3., das 5. Glied 1,1 × so lang wie das 4. und 1,5 × so lang wie das 3.

Pronotum (Fig. 2) kurz und breit, seine Seitenränder nach vorn kaum konvergierend, vom Grund bis zur Spitze sehr breit gerundet, Vorderrand sehr tief eingebuchtet und der Kopf daher tief eingesenkt. Oberseite punktiert mit Ausnahme des Hinterrandes und einer breiten Fläche quer über die Schwielen. Scutellum grob punktiert, spitz, seine Spitze niedergedrückt und abgerundet, mit etwas erhabenen Seiten. Corium gleichmässig und kräftig punktiert, Adern leistenartig erhaben; Aussenrand ohne Porenpunkte.

Unterseite fein punktiert, glänzend. Mündung der Stinkdrüsen (Fig. 41) breit, kurz und fast kreisrund; die matte Fläche der Mittelbrust reicht seitlich kaum weiter nach aussen als die der Hinterbrust und ist aussen gerade begrenzt; neben der matten Fläche der Hinterbrust eine Anzahl feiner Punkte, die 3 undeutliche Reihen bilden. Der Schnabel reicht bis zur Spitze der Mittelhüften. Beine schwarzbraun, Schienen mit langen schlanken Dornen, Tarsen hell.

Genitalsegment des ♂ (Fig. 51) viel länger als breit, distal deutlich verbreitert, proximal kaum gewölbt, Seiten daher fast gerade. Genitalgriffel (Fig. 64) mit fast rechtwinkliger Aussenkante, distal ein kleiner, nach aussen gerichteter Fortsatz, daneben gewölbt und lang behaart; innen distal mit undeutlichem Höcker, in der Mitte ein stark vorspringender, stumpfer Höcker; die bartartige Fläche dicht gekörnelt, leicht gewölbt und proximal gerundet. Penis (Fig. 78) gross und dick, die beiden Anhänge der Vesica kurz und kräftig, der innere etwas dicker und gerader.

Länge: ♂ (Holotypus) = 4,4 mm.

G. laticollis Reut. ist von allen übrigen Arten leicht durch die Form des Pronotum (Fig. 2) zu unterscheiden, dessen Seiten überall gleichmässig gerundet sind, aber auch der stark geneigte, lange Kopf (Fig. 15), der tief im Pronotum sitzt und der Bau der Genitalien trennen die Art gut von den übrigen. Auch das Fehlen von Haaren auf der Stirnschwiele und von Porenpunkten am Corumrand sind gute Merkmale. In der Gestalt gehört sie zum *elongatus*-Typ, neigt aber bereits ein wenig zur breiteren Form hinüber.

Von dieser Art sah ich neben der Holotype noch 3 ♀♀ aus Algier 1872 (Puton).

III. BESTIMMUNGSSCHLÜSSEL FÜR DIE EUROPÄISCHEN UND MEDITERRANEN ARTEN VON GEOTOMUS MULS.-REY

1 (2) Mittel- und Hinterbrust ohne matte Flächen, überall glänzend und kräftig punktiert. Scheitel 2,8-2,9 × so breit wie das grosse flache Auge ..... **12. G. intrusus nov. spec.**

2 (1) Mittel- und Hinterbrust mit matten Flächen. Scheitel über 3× so breit wie das Auge.

3 (4) Gestalt sehr breit (Fig. 1), der hintere Teil des Körpers (Halbdecken + Scutellum) etwa so lang wie breit. Die matten Flächen der Mittel- und Hinterbrust (Fig. 40) durch einen schmalen glänzenden Streifen getrennt..... **1. G. latiusculus Horv.**

4 (3) Hinterer Teil des Körpers mindestens 1,15× so lang wie breit. Matte Flächen der Mittel- und Hinterbrust einander berührend (Fig. 41-49).

5 (6) Pronotum nach vorn nicht verschmälert (Fig. 2); Kopf stark geneigt, von vorn gesehen so lang wie breit, tief ins Pronotum eingesenkt... ..... **2. G. laticollis Reut.**

6 (5) Pronotum nach vorn verschmälert; Kopf weniger tief eingesenkt.

7 (8) Fühler sehr schlank, das 2. Glied 1,25× so lang wie das 3. Gestalt vom *punctulatus*-Typ..... **3. G. antennatus Sign.**

8 (7) 2. Fühlerglied höchstens 1,1× so lang wie das 3.

9(16) Gestalt vom *elongatus*-Typ; Seiten des Corium im basalen Teil gerade und fast parallel (Fig. 9-13).

10(13) Corium am Seitenrand mit 3-5 borstentragenden Porenpunkten. Spitze der Stirnschwiele ohne lange Haare.

11(12) Halbdecken nach hinten deutlich etwas verschmälert (Fig. 11); 2. Fühlerglied 1,1× so lang wie das 3. ..... **9. G. longicornis nov. spec.**

12(11) Halbdecken nach hinten nicht verschmälert; 2. Fühlerglied so lang wie das 3. ..... **10. G. regnieri Vid.**

13(10) Corium am Seitenrand mit 1-2 borstentragenden Porenpunkten.

14(15) Länge des Tieres über 2× so gross wie die Breite des Pronotum. 5. Fühlerglied 1,3× so lang wie das 4. ..... **8. G. elongatus H. S.**

a (b) Spitze der Stirnschwiele ohne lange Haare. Gestalt grösser..... ..... **a. G. elongatus elongatus H. S.**

b (a) Spitze der Stirnschwiele mit 2 langen Haaren. Gestalt kleiner..... ..... **b. G. elongatus angustus nov. subspec.**

15(14) Länge des Tieres weniger als 2× so gross wie die Breite des Pronotum. 5. Fühlerglied 1,1× so lang wie das 4. Spitze der Stirnschwiele mit 2 langen Haaren..... **11. G. algiricus Vid.**

16 (9) Gestalt vom *punctulatus*-Typ; Aussenrand des Corium nach aussen gebogen (Fig. 4-8).

17(20) Stirnschwiele vorn mit 2 langen Haaren.

18(19) Körper im hinteren Drittel deutlich breiter als das Pronotum (Fig. 6). 5. Fühlerglied kürzer als des 4. ..... **6. G. simillimus nov. spec.**

19(18) Körper hinten nicht breiter als das Pronotum (Fig. 7+8). 5. Fühlerglied weit länger als das 4. ..... **7. G. caucasicus Klti.**

a (b) Länge über 4 mm. 2. Fühlerglied 0,75× so lang wie das 3. Matte Fläche der Mittelbrust (Fig. 46) distal spitz..... ..... **a. G. caucasicus caucasicus Klti.**

b (a) Länge unter 4 mm. 2. Fühlerglied 0,87× so lang wie das 3. Matte Fläche der Mittelbrust (Fig. 45) distal abgerundet..... ..... **b. G. caucasicus ciliatitylus Sign.**

20(17) Stirnschwiele frei von langen Haaren.

21(22) Scheitel 4,2-4,3× so breit wie das Auge. Genitalgriffel (Fig. 66) distal abgerundet, dicht und lang behaart. .... **5. G. brunnipennis nov. spec.**

22(21) Scheitel 3,8-3,9× so breit wie das Auge. Genitalgriffel (Fig. 66) distal eckig, weniger dicht und gröber behaart..... ..... **4. G. punctulatus Costa**

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Nachtrag zu meiner Arbeit "Einige neue Miridenarten aus Aegypten"

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[Hemiptera-Heteroptera]

von Eduard Wagner (Hamburg)

In der obigen Arbeit beschrieb ich auf S. 155 eine neue Miridengattung unter dem Namen *Paraminus*. Wie ich leider erst jetzt erfahre, ist dieser Name homonym zu *Paramimus* Huebner 1819 (Verz. bekannt. Schmetterl., 8, 115) Lepidoptera. Die Gattung muss daher einen anderen Namen erhalten und ich nenne sie *Mimocapsus* nov. gen.

The effect of previous infestation on host selection

(with 6 Tables)

by Dr. H. T. Zaazou,
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INTRODUCTION

In a previous paper (Zaazou, 1951), the writer discussed some factors affecting the host-selection principle which was defined by Hopkins (1917). It was found that the attraction of the favourite host was not constant, but varies according to the age of the insect. The chemical sense responsible for the choice of hosts varied according to the age of insects. It is usually very strong when the insects are young and gets weaker as they get older.

Another factor which may affect the selection of hosts, and which has been overlooked by most writers, is the previous infestation of hosts. Does insects prefer, for their oviposition, sound or infested hosts ? Why do they prefer one to the other ? Very few workers delt with the question before. Zacher (1929) stated that factors governing the female Bruchids in host-selection for oviposition are obscure, but the sense of smell is probably one and palpation another, since preference was shown for large seeds, and seeds with injured seed-coats were rejected. But Larson and Fisher (1938), after careful observation, stated that the female Bruchids usually search for beans which have cracked, or injured seed-coat, and oviposit on them beneath the seed-coat, so that the female Bruchid prefers cracked seeds for oviposition.

To investigate this factor, several experiments were conducted with three different Bruchids. They were *Bruchus* (*Acanthoscelides*) *obtectus* Say, *Bruchus* (*Callosobruchus*) *maculatus* F., and *Bruchus* (*Callosobruchus*) *chinensis* L. They were given the choice for oviposition between infested and sound hosts.

TECHNIQUE

The Bruchids as a whole are phototropic, so to eliminate the effect of light, all the experiments were conducted in complete darkness. Several Petri dishes were divided into eight equal compartments by cardboard stripes. There was an over head clearance of 1 cm. which allowed the contained insects free movements. The bottom as well as the edges of all the Petri dishes were covered with black paper. After introducing the Bruchids, all the dishes were covered with black muslin secured by rubber bands.

Four alternate compartments were filled with sound hosts. The remaining four compartments were filled with infested hosts. About thirty newly emerged Bruchids (1 to 2 days old) were scattered over the compartments. After five days' incubation eggs in every compartment were counted.

The experiments on *Bruchus* (*Acanthoscelides*) *obtectus* Say were carried out at constant temperature of 25° C, while those on *Bruchus* (*Callosobruchus*) *maculatus* F. and *chinensis* L. were carried out at room temperature which fluctuated from 23° to 28° C.

Bruchus (Acanthoscelides) obtectus Say

The different hosts used were red and white kidney beans. Four alternate compartments were filled with sound red and white kidney beans and the gaps between them were filled alternatively with the two sorts of infested beans. The experiment was repeated four times, and in each repetition the arrangement of the hosts was the same. About thirty newly e-

TABLE I

Bruchus obtectus L.

HOSTS	A		B		C		D		AVERAGE	
	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%
Infested red kidney beans	13	5.8	14	4.4	19	6.7	15	7.5	15.3	6.1
Sound red kidney beans.....	65	29.0	165	52.5	105	37.3	82	38.5	104.2	39.3
Infested white kidney beans...	29	12.9	26	8.3	16	5.6	24	11.2	23.5	9.5
Sound white kidney beans....	117	52.2	109	34.5	142	50.4	92	43.1	115.0	45 0

Total percentage of infested beans: 15.6. — Total percentage of sound beans: 84.3.

merged Bruchids which had been reared on red kidney beans were scattered over the compartments. After five days' incubation, eggs in every compartment were counted, the results are shown in Table I.

The preference shown by the females for sound beans is very striking and is noticed in both white and red kidney beans. Not less than 84% of all the eggs laid by the females were deposited on sound beans, while 15% were deposited on infested beans.

Bruchus (Callosobruchus) maculatus F.

To obtain further information, more experiments were carried out with *Bruchus (Callosobruchus) maculatus* F. (the cow-pea weevil). The different hosts used were sound and infested cow-pea and broad bean. The Bruchids used were reared on broad beans for nearly six months. The results of the experiment which was repeated four times are shown in Table II.

TABLE II

Bruchus (Callosobruchus) maculatus F.

HOSTS	A		B		C		D		AVERAGE	
	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%
Infested broad beans	21	6.48	11	4.70	26	7.10	9	4.1	17.0	5.9
Sound broad beans	119	38.70	89	38.60	113	31.05	73	33.3	98.5	34.5
Infested cow-peas	17	5.20	14	6.60	19	5.22	12	5.5	15.5	5.4
Sound cow-peas	167	51.50	117	50.65	206	56.60	125	57.1	154.0	54.1

Total percentage of infested beans: 11.3. — Total percentage of sound beans: 88.6,

The preference of sound beans is also very striking, about 85% of the eggs were deposited on sound beans, while the infested ones received only about 15 %.

Bruchus (Callosobruchus) chinensis L.

The same experiments were repeated with *Bruchus (Callosobruchus) chinensis* L. The hosts used were sound and infested broad beans and cow-pea. The Bruchids used were reared on broad beans. The results are shown in Table III.

These results indicated that all the three Bruchids preferred sound beans to infested ones for oviposition. In each species of the Bruchids used, sound beans received more than 85 % of all the eggs deposited by the females, while the infested beans received only about 15 %.

What is this descrimination due to ?

There are two major differences between infested and sound beans: (a) infested beans have a peculiar smell which can easily be detected. This

smell might act as a repellent, keeping the female Bruchids away ; (b) infested beans usually have holes in them, making them unsuitable for the development of the larvae.

TABLE III

Bruchus (Callosobruchus) chinensis L.

HOSTS	A		B		C		D		AVERAGE	
	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%	NUMBER OF EGGS	%
Infested broad beans	15	6.5	11	6.07	19	6.1	13	4.98	14.5	8.8
Sound broad beans	85	36.7	76	42.00	103	33.4	99	37.78	90.7	36.5
Infested cow-peas	19	8.2	9	5.00	21	6.8	16	6.10	18.7	7.5
Sound cow-peas	112	48.4	85	46.90	165	53.5	134	51.10	12.4	50.1

Total percentage of infested beans : 13.3. — Total percentage of sound beans : 86.6.

Zacher (1929) stated that factors governing the females of *Bruchus obtectus* Say in host-selection for oviposition are obscure, but the sense of smell is probably one and palpation another, since preference was shown for large seeds and seeds with injured seed-coats were rejected.

According to Zacher's views, this discrimination between sound and infested beans is due to the smell of the infested seeds as well as to the

TABLE IV

Bruchus (Acanthoscelides) obtectus Say

HOSTS	A	B	C	D	AVERAGE	
	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	%
Red kidney beans with artificial holes	74	84	141	84	95.7	22.9
Sound red kidney beans	53	119	119	32	80.9	19.3
White kidney beans with artificial holes	117	135	93	113	114.5	27.4
Sound white kidney beans	125	148	125	108	126.5	30.3

Total percentage of eggs laid on beans with artificial holes : 50.3
Total percentage of eggs laid on sound beans : 49.6

holes (injury) in them. But Larson and Fisher (1938), after careful observations, stated that the female Bruchid usually searches for the beans which have cracked or injured seed-coat and oviposits on them beneath the seed-coat, so that the female Bruchid prefers cracked seeds for oviposition.

So, to find out whether injured seeds, which have not got the peculiar smell of the infested beans, will be chosen or rejected by the female Bruchid for oviposition, a series of experiments were conducted with artificially injured sound beans. Holes were made with a dissecting needle in the different sound beans used as hosts for each of the three Bruchids. These holes looked as nearly as possible like the holes made by the emerging Bruchids. From 2 to 4 holes were made in every bean, and some beans were also cracked very slightly, just enough to injure the seed-coat.

TABLE V

Bruchus (Callosobruchus) maculatus F.

HOSTS	A	B	C	D	AVERAGE	
	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	%
Broad beans with artificial holes.....	65	78	116	127	96.5	25.2
Sound broad beans	49	99	122	119	99.7	26.2
Cow-peas with artificial holes.....	112	65	79	89	86.2	22.7
Sound cow-peas	119	82	85	105	97.7	25.7

Total percentage of eggs laid on beans with artificial holes : 47.9
Total percentage of eggs laid on sound beans : 51.9

TABLE VI

Bruchus (Callosobruchus) chinensis L.

HOSTS	A	B	C	D	AVERAGE	
	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	NUMBER OF EGGS	%
Broad beans with artificial holes.....	98	63	95	74	82.5	22.3
Sound broad beans	110	85	86	65	86.5	23.4
Cow-peas with artificial holes.....	127	107	58	103	98.7	26.7
Sound cow-peas	116	98	94	98	101.5	27.5

Total percentage of eggs laid on beans with artificial holes : 49
Total percentage of eggs laid on sound beans : 50.9

The apparatus used and the arrangement of the hosts in the different compartments were exactly the same as described in the previous experiments, with only one difference: infested beans were replaced by sound beans with artificial holes. The arrangement of the seeds in the compart-

ments was: one compartment filled with sound beans, the next one filled with sound beans with artificial holes and so on. About 40 newly emerged Bruchids (1 to 2 days old) were scattered over the compartments. Eggs in every compartment were counted after an incubation period of 5 days. The results of every experiment, which was repeated four times, are shown in Tables IV, V, and VI.

These results show that there is no appreciable difference between the average number of eggs laid on sound beans and on artificially injured beans. Sound red and white kidney beans received 49.3 % of the total eggs, while those with holes rceeived 50.7 %, a very insignificant difference. In the case of *Bruchus* (*Callosobruchus*) *maculatus* F. and *chinensis* L., the sound beans received 51.9 and 50.9 % of the total eggs, while those with holes received 47.9 and 49 % of the eggs laid by the female Bruchids.

These results indicate that the Bruchids used deposit nearly equal number of eggs on sound beans whether they are in good condition, cracked, or have artificial holes made in them.

It is clear now that the Bruchids preferred sound beans to infested ones, mainly because of the peculiar smell of the infested beans. Holes or cracks in the beans did not prevent the female Bruchid from ovipositing. Infested beans did not receive more than 15 % of the total eggs laid by the females. This low percentage of eggs deposited on infested beans is mainly, if not solely, due to their smell which repelled the females.

It was observed that the majority of the eggs laid on beans with artificial holes or cracks, were laid in the holes or around them. This confirms the observation of Larson and Fisher (1938), that the female when ovipositing on cracked beans or on beans with injured seed-coats usually oviposits beneath the seed-coat of the bean or quite near the crack. This indicates that palpation as well as the sense of smell plays a major part in the selection of the host for oviposition in the three Bruchids used.

SUMMARY

(1) Sound beans are preferred for oviposition to infested beans.

(2) Infested beans did not receive more than the 15 % of the total eggs laid by the females.

(3) The preference of sound beans is due mainly to the peculiar smell of the infested beans which repelled the female Bruchids.

(4) Artificial holes or cracks in the sound beans did not increase the number of eggs laid on them. Cracked and sound hosts received nearly equal number of eggs.

(5) Females ovipositing on cracked beans or beans with injured seed-

coat usually oviposit beneath the seed-coat of the bean or quite near the crack.

(6) Palpation as well as the sense of smell plays a major part in selecting the host for oviposition.

ACKNOWLEDGMENTS

The part dealing with *Bruchus obtectus* Say was carried out at the Biological Field Station Slough (England). The rest dealing with *Bruchus* (*Callosobruchus*) *maculatus* F. and *chinensis* L. was carried at the Ministry of Agriculture, Cairo. I am indebted to Mohamed Soliman El-Zoheiry Bey, the Director General of the Plant Protection Department, for his advise and support. My thanks are also due to Mr. Rizk Attia for helping and supplying the material used in this work.

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Olive pests hirtherto unrecorded from Egypt

[Lepidoptera: Tineidae]

by I. Famhy, B.Sc. (Edin.), Ph.D. (Edin.),
Entomologist

Glyphodes unionalis Hb.

Although this moth has been collected very long ago in Marsa Matrouh, the Mariout, Ramleh (Alexandria), Helwan, Maadi, and Koubbeh, always at lamp light, it is known since 1931 as damaging olive trees in the Mariout district. However, very little is known at present on the amount of damage caused to olive trees by this pest of the Oleineae, which was already recorded to attack mainly Jasmin and Olive in other countries.

Its distribution is Mediterranean. It also occurs in Mauritania, Madeira, Canary islands, and in the Indo-Australian region.

Prays oleellus F.

A pest of olive trees in the Mediterranean region and Mauritania.

This insect was hitherto unknown in Egypt. The author found it doing extensive damage to olive trees, both young nursery and bearing trees, at Abulmatamir (Behera). It is also reported doing similar damage at Borg El-Arab (Mariut) and Marsa Matrouh in the Mediterranean coastal region of this country.

The moth is greyish, with two distinct darker areas in the middle of the forewings, the span of which varies from 13 to 16 mms.

Caterpillars are extremely active, spin tender leaves together, feeding in this leaf-web. Developing leaf buds are preferred, and often one finds a great number of leaves totally destroyed. Flower buds and blossoms are webbed together, attacked and destroyed. Later, the fruit is attacked, the caterpillars penetrating into the seed. In all cases great damage is caused.

The caterpillars occur in greatest abundance in January, February and March, attacking terminal buds. A favourable habitat for pupation is the underside of leaves of suckers growing at the bases of trees, close to the soil, a situation favoured by humid conditions.

During April and May, caterpillars attack flower buds and blossoms. From July onwards, olives also are attacked.

During this season, however, active measures for the control of the olive fly, *Dacus oleae* Gmel., have resulted in keeping *Prays* damage in check.

The author gratefully acknowledges the assistance of Dr. J. Klimesch and Prof. Dr. H. Priesner in the identification of this species. He also expresses his appreciation for the co-operation of Mr. N. Pierrakos of the Gianaclis Estates at Abulmatamir who made possible this study.

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CORRIGENDA

du

Bulletin de la Société Fouad 1er d'Entomologie, volume XXXVI, 1952

Page 157, ligne 12 : *pour* from *lire* form.

Page 169, ligne 1 : *pour* two moths *lire* the moth.

Page 179, ligne 13 : *pour* eaten *lire* beaten.

Page 179, lignes 28, 31, 33 et 34 : pour *nigrimaculata* lire *bimaculata*.

Page 186, ligne 8 : pour *bimaculata nigrimaculata* Wilts. lire *bimaculata* Osthelder.

Pages 187-210 : Cet article est le XIe de la série et non pas le Xe comme indiqué. L'article précédent, publié dans ce Bulletin, volume XXXIII, 1949, pages 353-372, n'est pas le IXe, mais le Xe.

Page 189, ligne 1 : *pour* billy *lire* hilly.

Page 189, ligne 12 : *après* structure *ajouter* of adult.

Page 190, ligne 9 : *pour* 19.ix.49 *lire* 19.xi.49.

Page 195, explication de la figure 5 : *ajouter* C=corona, H=harpe.

Page 204, ligne 10 : *pour* Calium *lire* Galium.

Page 207, ligne 1 : *pour* mucus *lire* uncus.

Page 220, Table VII et Table VIII : *pour* TOTAL NUMBER OF EGGS LAID PER FEMALE *lire* INCUBATION PERIOD IN DAYS.

Page 249, 3 ligne avant la fin : *pour* The labrum (Fig. 7) is articulated *lire* On each side of the clypeus dorsal.

Page 259, ligne 16 : *pour* into which articulates the condyle of the trochanter (TR). The trochanter *lire* like condyle, which fits into the fossa of the coxa. Distally the trochanter.

Page 311, ligne 7 de l'Introduction : *pour* fourth an fifth *lire* fourth and fifth.

Page 312, ligne 23 : *pour* author's lire authors.

Page 312, dernière ligne : *pour* past *lire* part.

Page 314, ligne 10 : *pour* theory by *lire* theory of.

Page 315, ligne 22 : *pour* was *lire* were.

Page 321, 5e ligne avant la fin : *pour* date *lire* data.

Page 327, Table VI : *pour* 14.XII.1950 *lire* 17.XII.1950.

Page 328, ligne 33 : *pour* icreases *lire* increases.

Page 328, dernière ligne : *pour* page 17 *lire* page 327.

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مجلة
جمعية فؤاد الأول لعلم الحشرات

سابقا :
جمعية الحشرات المصرية (١٩٠٧ - ١٩٢١)
والجمعية الملكية المصرية لعلم الحشرات (١٩٢٢ - ١٩٣٧)

تأسست فى أول اغسطس سنة ١٩٠٧

وضعت تحت رعاية الحكومة المصرية بمرسوم ملكى
فى ١٥ مايو سنة ١٩٢٣

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